Report

Development of Emission Rate Lookup Tables (ERLTs)

TxDOT Environmental Affairs Division
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EXECUTIVE SUMMARY

This project updated the emission rate lookup tables (ERLTs) developed in 2016 by incorporating changes such as updates to the Environmental Protection Agency's (EPA's) motor vehicle emissions model (MOVES2014b), vehicle and fuel characteristics, weather characteristics, and vehicle miles traveled (VMT) mix.

As per National Environmental Policy Act (NEPA) and Clean Air Act Amendments of 1990 (CAAA), the Texas Department of Transportation (TxDOT) has to routinely investigate the air quality impact of proposed transportation projects and mitigation strategies. The crucial input for conducting the air quality emissions analysis at the project level is the ERLT. These tables provide emission rates needed to convert quantities such as vehicle miles traveled, intersection delays, truck stop idling, and vehicular starts to total emissions.

This study computes the ERLTs for criteria air pollutants and mobile source air toxics (MSAT). These pollutants are regulated under the CAAA and need to be incorporated in various air quality assessments. Criteria air pollutants are regulated, as they are considered harmful to public health and the environment. MSAT is regulated, as they are regional-scale cancer risk drivers or contributors and non-cancer hazard contributors. Criteria air pollutants include ozone (O_3), carbon monoxide (CO), particulate matter (PM), nitrogen dioxides (NO_2), sulfur dioxide (SO_2), and lead (Pb). MSAT includes 1,3-butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter (diesel PM), ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter (POM).

ERLTs developed in this study provide emission rates for analysis years 2020 through 2050 for the following TxDOT Districts: Dallas & Fort Worth (DAL & FTW); Houston (HOU); Austin (AUS); Beaumont (BMT); San Antonio (SAT); El Paso (ELP); Corpus Christi (CRP); and Waco (WAC). These nine districts cover eight of the state's major metropolitan areas. The emission rates are further split into the following categories:

1. Running emission rates (gram/mile) by average speed and road type.
2. Start emission rates (gram/start) by vehicle and fuel type combination.
3. Extended idling emission rates (gram/hour) for combination long-haul trucks.
4. Idling emission rates (gram/hour).

This study uses the latest version of EPA's MOVES (MOVES2014b) available at the time of this study (October 2020). MOVES2014b includes a default database of emission-relevant information (e.g., fleet composition and activity, emission rates, fuels, meteorology, emission control programs) for the entire United States. Multiple MOVES defaults were replaced by alternate input datasets that better reflect analysis year and local scenario conditions. Tables including the weather and fleet characteristics, fuel properties, inspection maintenance (I/M) program coverage, MOVES hotelling hour distribution table were updated with analysis year and district/county specific tables.

For each analysis district, TTI staff conducted MOVES county-scale runs for a representative county for even years between 2020 to 2050 for January, April, July, and October. Emission

rates for odd years were obtained by linear interpolation. Each hour of the day is modeled in county-scale runs. Running, start, and extended idling vehicular process emission rates are obtained from county-scale runs.

For each analysis district, TTI staff conducted MOVES project-scale runs for a representative county for even years between 2020 to 2050 for January, April, July, and October. Four periods: AM peak (8–9 AM), Midday (3–4 PM), PM peak (6–7 PM), and Overnight (11 PM-Midnight) are modeled in project-scale runs. Idling process emission rates are obtained from project-scale runs.

TTI staff incorporated hourly activity factors or hour mixes into emission rates to decompose daily activities such as daily VMT, starts, and hotelling hours implicitly into hourly VMT, starts, and hotelling hours. Hour mixes vary by analysis district. Moreover, TTI staff incorporated vehicle-fuel type distribution factors into the emission rates to decompose activities such as hourly VMT or idling hours into hourly VMT or idling hours by each vehicle-fuel type combination. Vehicle-fuel type distribution factors vary by time of day, road type, and analysis year. TxLED factors were also incorporated in the emission rates to reduce nitrogen oxides (NO_X) emissions due to TxLED programs in various Texas districts. TxLED factors vary by analysis year and vehicle type.

TTI staff obtained intermediate composite rate tables after incorporating hourly activity factors, vehicle-fuel type distribution factors, and TxLED factors to the running, start, idling, and extended idling emission rates. These intermediate composite rate tables provided the following emission rates for each analysis district and year combination:

1. Running emission rates (gram/mile) for January, April, July, and October by average speed and road type.
2. Start emission rates (gram/start) for January, April, July, and October by vehicle and fuel type combination.
3. Extended idling emission rates (gram/hour) for January, April, July, and October for combination long-haul trucks.
4. Idling emission rates (gram/hour) for four months: January, April, July, and October and four periods: AM peak, PM peak, Midday, and Overnight.

Yearly ERLTs were then developed for running, start, and extended idling process by taking the maximum of emission rates between different seasons. Idling yearly ERTLs were developed by taking the maximum emission rates within the 16 season-period combinations (representing the four time-of-day periods in each of the four months).

Running, start, extended idling, and idling composite factors, in the form of ERLTs for the various pollutants, years, and other relevant groupings such as roadway type, speeds, and process type are provided in MS-Excel® spreadsheet format as the final output of this project, along with the necessary supporting documentation.

INTRODUCTION

As part of an interagency contract with the Texas Department of Transportation (TxDOT), the Texas A&M Transportation Institute (TTI) developed a new set of emission rate lookup tables (ERLTs) for criteria pollutants and mobile source air toxics (MSAT) using the United States Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES) emissions model. This work was performed following the methodology outlined in the *Development of Emission Rate Lookup Tables Final Work Plan* dated October 15, 2020, submitted by TTI to TxDOT. TTI was approved to proceed with the workplan following review by TxDOT and the Federal Highway Administration (FHWA). This work consisted of three tasks, as follows:

- Task 1. Develop draft and final work plans
- Task 2. Develop draft and final ERLTs
- Task 3. Prepare supporting analyses and documentation

This document details the activities TTI performed in the development of the ERLTs.

BACKGROUND

TxDOT and its contractors use on-road emission rates developed and regularly updated for various areas in Texas to fulfill Federal Highway Administration (FHWA), Environmental Protection Agency (EPA), and Council on Environmental Quality (CEQ) air quality requirements for transportation projects. Emission rates development for such applications is required to adhere to the guidance provided by FHWA and EPA and employ the latest emissions model and data available. These emission rates should demonstrate technical equivalency and defensibility for use under the National Environmental Policy Act (NEPA).

The NEPA of 1969 established a systematic framework to ensure major transportation projects receiving federal support undergo a review that considers the project's environmental consequences (*1*). A NEPA review considers the potential impacts of proposed projects on resources such as water, endangered species, human environments, and air quality (*2*). In accordance with NEPA, the FHWA and partner agencies, notably state Departments of Transportation (DOTs), are tasked with assessing the impacts of proposed transportation projects on air quality and investigating mitigation strategies.

The Clean Air Act Amendments of 1990 (CAAA) requires the EPA to set National Ambient Air Quality Standards (NAAQS) (40 Code of Federal Regulations; CFR, Part 50) for pollutants considered harmful to public health and the environment, including six principal pollutants, which are called "criteria air pollutants." These are ozone (O_3), carbon monoxide (CO), particulate matter (PM), nitrogen dioxides (NO_2), sulfur dioxide (SO_2), and lead (Pb).

1. U.S. Government Publishing Office. United States Code. Accessed at: https://www.gpo.gov/fdsys/browse/collectionUScode.action?collectionCode=USCODE.

2. U.S. EPA, Summary of the National Environmental Policy Act. 2015. Accessed at: https://www.epa.gov/laws-regulations/summary-national-environmental-policy-act.

The EPA's transportation conformity rule (40 CFR 51.390 and Part 93) establishes the criteria and procedures for determining whether transportation projects and programs conform to the state implementation plan (SIP). Transportation conformity applies to transportation activities in nonattainment and maintenance areas for transportation-related pollutants, including ozone, CO, NO_2, $PM_{2.5}$, and PM_{10}. All non-exempt projects in such nonattainment and maintenance areas must be consistent with the regional conformity determinations of the metropolitan transportation plans. In addition, projects in CO, $PM_{2.5}$, or PM_{10} nonattainment or maintenance areas are potentially subject to hot-spot analyses. The EPA's established hot-spot guidance is based on regulations and guidance for CO and PM NAAQS, SIP development, and other applicable regulatory programs (*3*).

The CAAA also mandated the EPA to regulate and control hazardous air pollutants (HAPs), including those from mobile sources. Section 112(b) of the CAAA contains a list of HAPs the EPA is required to control through regulatory standards (*4*). A subset of these pollutants are considered to be MSAT. These include 1,3-butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter (diesel PM), ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter (POM). The EPA defines these MSAT as regional-scale cancer risk drivers or contributors and non-cancer hazard contributors in the 2014 National Air Toxics Assessment (*5*). The CAAA does establish requirments for project-level MSAT analyses for transportation projects.

In order to address NEPA regulatory requirements at the project level, FHWA has issued guidance for CO in their T-6640.8A document and interim guidance for MSAT. The T-6640.8A NEPA guidance has not been updated since October of 1987. Updates are released regularly to reflect regulatory changes, new scientific research, and new methods or tools to conduct MSAT analyses. The FHWA provided initial guidance to address project-level MSAT impacts for transportation projects under NEPA in 2006, based on priority MSAT identified in the EPA's 2001 MSAT rule. Updates to the guidance were released in 2009, 2012, and 2016. The FHWA also provides responses to a set of frequently asked questions—last updated in 2016—that supplement the guidance documents with detailed recommendations for conducting MSAT analyses. Table 1 lists the different guidance documents from FHWA on MSAT, including the priority MSAT covered and the applicable emissions model.

3. U.S. EPA. Project-Level Conformity and Hot-Spot Analyses. Accessed at: https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses.

4. U.S. EPA. Overview by Section of CAA. Air Toxics. 2016. Accessed at: https://www3.epa.gov/airtoxics/overview.html.

5. U.S. EPA. National Air Toxics Assessment; Accessed at: https://www.epa.gov/national-air-toxics-assessment.

Table 1. Summary of FHWA MSAT Guidance.

Year	Priority MSAT	Model for Emissions Rate Development
2006 (*6*)	Benzene, 1,3-butadiene, formaldehyde, acrolein, acetaldehyde, and diesel exhaust organic matter and diesel particulate matter (DPM)	MOBILE6.2
2009 (*7*)	Acrolein, benzene, 1,3-butadiene, diesel particulate matter (DPM) plus diesel exhaust organic gases, formaldehyde, naphthalene, and polycyclic organic matter (POM)	MOBILE6.2
2012 (*8*)	No change	MOVES2010 replaces MOBILE6.2
2016 (*9*)	Reinstated acetaldehyde and added ethylbenzene	MOVES2014a

The EPA's newest emission model, MOVES, has emerged as the preferred emissions modeling platform for a range of regulatory and research purposes. The EPA has mandated using MOVES for all official air quality estimations in the United States, except California. MOVES provides a suitable platform for estimating on-road emissions because it is a modal-based model that estimates emissions based on a unique combination of modes (or bins) representing vehicle operating conditions and vehicle characteristics. TTI used MOVES in developing the emission rates for this study.

During the start of this analysis, MOVES2014b (released in August 2018) was the latest version of EPA's motor vehicle emissions model for state and local agencies to estimate emissions of nitrogen oxides (NO_X), volatile organic compounds (VOC), PM, and other pollutants from cars, trucks, buses, and motorcycles for SIP purposes and conformity determinations. MOVES2014b is also the preferred emissions model for project-level MSAT and hot-spot analyses. MOVES2014b includes a default database of emission-relevant information (e.g., fleet

6. Transportation Research Board, NCHRP 25-25 (71): Project-Level Analysis Template. 2012. Accessed at: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25(71)_Template.pdf.

7. U.S. Department of Transportation, Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA Documents. 2009, Federal Highway Administration. Accessed at: https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/100109guidmem.cfm.

8. U.S. Department of Transportation, Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents. 2016, Federal Highway Administration. Accessed at: https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/msat/index.cfm.

9. U.S. Department of Transportation, Frequently Asked Questions (FAQ) Conducting Quantitative MSAT Analysis for FHWA NEPA Documents. 2017, Federal Highway Administration. Accessed at: http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/moves_msat_faq.cfm.

composition and activity, emission rates, fuels, meteorology, emission control programs) for the entire United States. The EPA continually works to improve this database with more precise activity data that can advance local, state, and federal government's understanding of how, when, and where emissions are emitted. It also recommends that local data be used for emissions estimations for SIP and transportation conformity analyses (*10*). TTI used MOVES2014b for this analysis.

STUDY SCOPE

According to the plan, TTI developed ERLTs for the analysis years 2020 through 2050 with MOVES2014b for the following TxDOT Districts: Dallas & Fort Worth (DAL & FTW); Houston (HOU); Austin (AUS); Beaumont (BMT); San Antonio (SAT); El Paso (ELP); Corpus Christi (CRP); and Waco (WAC). These nine districts cover eight of the State's major metropolitan areas. The pollutants and pollutant aggregates included in the ERLTs are listed in Appendix A – MOVES Pollutants Modeled. TTI employed the latest available data to develop inputs required for MOVES2014b. In the remainder of this document, "MOVES" refers to the model version (MOVES2014b) used for this work. TTI used recently released and analyzed, latest available (2018) Texas Department of Motor Vehicles (TxDMV) vehicle registrations data in developing MOVES inputs. The following section documents detailed activities conducted in the development of the emission rate tables.

METHODOLOGY AND ASSUMPTIONS

This section provides the detailed steps for estimating composite emission rates lookup tables for nine TxDOT districts covering the eight metropolitan areas of the State, as mentioned in the previous section. Table 2 lists each district's component counties and the representative county TTI used in the MOVES emission rates modeling.

10. Environmental Protection Agency (2018), MOVES2014 and MOVES2014a, and MOVES2014b Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, Accessed at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100V7EY.pdf.

Table 2. TxDOT Districts and Representative Counties used for Emission Rate Modeling.

TxDOT District	Counties in the District	Representative County for Emission Rate Runs
1. Austin	Bastrop, Blanco, Burnet, Caldwell, Gillespie, Hays, Lee, Llano, Mason, Travis, and Williamson	Travis
2. Beaumont	Chambers, Hardin, Jasper, Jefferson, Liberty, Newton, Orange, and Tyler	Jefferson
3. Corpus Christi	Aransas, Bee, Goliad, Jim Wells, Karnes, Kleberg, Live Oak, Nueces, Refugio, and San Patricio	Nueces
4. Dallas	Collin, Dallas, Denton, Ellis, Kaufman, Navarro, and Rockwall	Dallas
5. El Paso	Brewster, Culberson, El Paso, Hudspeth, Jeff Davis, and Presidio	El Paso
6. Fort Worth	Erath, Hood, Jack, Johnson, Palo Pinto, Parker, Somervell, Tarrant, and Wise	Tarrant
7. Houston	Brazoria, Fort Bend, Galveston, Harris, Montgomery, and Waller	Harris
8. San Antonio	Atascosa, Bandera, Bexar, Comal, Frio, Guadalupe, Kendall, Kerr, McMullen, Medina, Uvalde, and Wilson	Bexar
9. Waco	Bell, Bosque, Coryell, Falls, Hamilton, Hill, Limestone, and McLennan	McLennan

TTI conducted 20 runs for each TxDOT district for each of 16 analysis years (2020 through 2050 with an increment of 2 years) (*11*), a total of 2,880 runs for all analysis years, and the nine TxDOT districts combined. Four county-scale runs (spring, summer, fall, and winter seasons) were used to estimate running, start, and extended idle ERLTs. Sixteen project-scale runs (spring, summer, fall, and winter seasons) for morning peak (AM), Midday (MD), evening peak (PM), and overnight (ON) periods of the day were used to estimate idling ERLTs.

MOVES defaults may be replaced by alternate input data sets that better reflect local scenario conditions. Where available and consistent with the methodology outlined in the workplan, local data was used in place of MOVES default data via the MOVES Run Specification (MRS) input file (also referred to as RunSpec files) and the MOVES local input database (*12*). The process used for developing the composite ERLTs based on the pollutant, emission process, speed, roadway type, and other factors consisted of these five steps:

1. Production of MOVES run specification files
2. Development of MOVES county and project input databases

11. TTI employed a linear interpolation technique to estimate emission rates for the years not directly modeled using MOVES.

12. The MRS files, local input databases, and MOVES default database provide the input data tailored for each local scenario.

3. Execution of MOVES emission rate runs
4. Creation of vehicle type VMT mixes, hourly VMT distributions, and TxLED Factors
5. Estimation of composite emission rates

The following sections provide detailed information on each step.

STEP 1 – PRODUCTION OF MOVES RUN SPECIFICATION (MRS) FILES

The MRS is a file (in XML format) that defines the place, time, road categories, vehicle and fuel types, pollutants and emissions processes, and the overall scale and level of output detail for the modeling scenario. TTI created an MRS for one county using the MOVES graphical user interface (GUI), converted this MRS to a template, and used it as a base from which to build all the needed MRSs. TTI created RunSpecs for both county-scale and project-scale analyses needed for the emissions rates runs. For this analysis, TTI staff developed 2,880 RunSpecs for all analysis years and the nine TxDOT districts combined. Table 3 and Table 4 describe the MRS selections that were used for creating county-scale and project-scale RunSpecs.

Table 3. MOVES Graphical User Interface Panel Selections – County-scale Runs.

Navigation Panel	Detail Panel[1]	Selection		
Scale[1]	Model; Domain/Scale; Calculation Type	On-Road; County; Emissions Rates		
Time Spans[1]	Time Aggregation Level; Years – Months – Days – Hours	Hour; 2020 through 2050[1] – Jan, April, July, Oct – Weekday - All		
Geographic Bounds[1]	Region; Selections; Domain Input Database	Zone and Link; ***<COUNTY>;***[1] ***<COUNTY INPUT DATABASE (CDB) NAME>***[1]		
On-Road Vehicle Equipment	SUT/Fuel Combinations	SUT	Gasoline	Diesel
		Motorcycle	X	-
		Passenger Car	X	X
		Passenger Truck	X	X
		Light Commercial Truck	X	X
		Intercity Bus	-	X
		Transit Bus	-	X
		School Bus	X	X
		Refuse Truck	X	X
		Single Unit Short-Haul Truck	X	X
		Single Unit Long-Haul Truck	X	X
		Motor Home	X	X
		Combination Short-Haul Truck	X	X
		Combination Long-Haul Truck	-	X
Road Type	Selected Road Types	Off-Network – Rural Restricted Access – Rural Unrestricted Access – Urban Restricted Access – Urban Unrestricted Access		

Navigation Panel	Detail Panel[1]	Selection
Pollutants[2] and Processes	Carbon monoxide (CO), Particulate Matter – 10 Micrometer or less (PM_{10}), Particulate Matter – 2.5 Micrometer or less ($PM_{2.5}$), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Nitrogen Oxides (NO_X), Volatile Organic Compounds (VOC), Carbon Dioxide Equivalent (CO_{2eq}), Acrolein (ACROL), Acetaldehyde (ACTE) Benzene (BENZ), 1,3-butadiene (BUTA), Diesel Particulate Matter (DPM)[3], Ethylbenzene (ETYB), Formaldehyde (FORM), Naphthalene (NAP), and Polycyclic Organic Matter (POM)[4]	Dependent on pollutant: Running Exhaust, Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Crankcase Extended Idle Exhaust, Evap Permeation, Fuel Vapor Venting, Fuel Leaks, Brakewear, Tirewear
Manage Input Data Sets	Additional Input Database Selections	None
Strategies	Rate of Progress	Not Applicable
General Output	Output Database; Units; Activity	***<MOVES OUTPUT DATABASE NAME>***;[1] grams, Joules, Miles; Hotelling Hours, Population, Starts (pre-selected)
Output Emissions Detail	Always; For All Vehicles/Equipment; On-Road	Time: Hour – Location: Link – Pollutant; Fuel Type, Emissions Process; Road Type, Source Use Type
Advanced Performance Measures	Aggregation and Data Handling	Check the "clear BaseRate output after rate calculations" box

1 County scale allows only one county and year per run. Geographic and temporal identifiers were included in the MRS file names and the CDB names, and output database names. One output database was produced, specific to each MRS file. One representative county from each TxDOT district was modeled to estimate emission rates representative of the districts.

2 Some of these pollutants require other "base" pollutants (not listed in the table) to be selected in the MRS (e.g., VOC requires Total Gaseous Hydrocarbons and Non-Methane Hydrocarbons; Atmospheric CO2 requires Total Energy Consumption; PM2.5 includes several subcomponents, e.g., elemental carbon, organic carbon, sulfate).

3 DPM is diesel emissions of organic carbon, elemental carbon, and sulfates.

4 POM emissions are estimated using the most predominant POM pollutants, listed below, without NAP: Acenaphthene, Acenaphthylene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3,c,d)pyrene, Phenanthrene, and Pyrene.

Table 4. MOVES Graphical User Interface Panel Selections - Project-scale Runs.

Navigation Panel	Detail Panel[1]	Selection		
Scale[1]	Model; Domain/Scale; Calculation Type	On-Road; Project; Inventory		
Time Spans[1]	Time Aggregation Level; Years – Months – Days – Hours	Hour; 2020 through 2050[1] – Jan, April, July, Oct – Weekday – MOVES hourid 8 (AM Peak), 15 (Midday), 18 (PM Peak), 23 (Overnight)		
Geographic Bounds[1]	Region; Selections; Domain Input Database	County; ***<COUNTY>;***[1] ***<PROJECT-SCALE INPUT DATABASE (PDB) NAME>***[1]		
On-Road Vehicle Equipment	SUT/Fuel Combinations	SUT	Gasoline	Diesel
		Motorcycle	X	-
		Passenger Car	X	X
		Passenger Truck	X	X
		Light Commercial Truck	X	X
		Intercity Bus	-	X
		Transit Bus	-	X
		School Bus	X	X
		Refuse Truck	X	X
		Single Unit Short-Haul Truck	X	X
		Single Unit Long-Haul Truck	X	X
		Motor Home	X	X
		Combination Short-Haul Truck	X	X
		Combination Long-Haul Truck	-	X
Road Type	Selected Road Types	Urban Restricted Access (all roadways provide the same emission rates for idling)		

Navigation Panel	Detail Panel[1]	Selection
Pollutants[2] and Processes	Carbon monoxide (CO), Particulate Matter – 10 Micrometer or less (PM_{10}), Particulate Matter – 2.5 Micrometer or less ($PM_{2.5}$), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Nitrogen Oxides (NO_X), Volatile Organic Compounds (VOC), Carbon Dioxide Equivalent (CO_{2eq}), Acrolein (ACROL), Acetaldehyde (ACTE) Benzene (BENZ), 1,3-butadiene (BUTA), Diesel Particulate Matter (DPM)[3], Ethylbenzene (ETYB), Formaldehyde (FORM), Naphthalene (NAP), and Polycyclic Organic Matter (POM)[4]	Dependent on pollutant: Idling
Manage Input Data Sets	Additional Input Database Selections	None
Strategies	Rate of Progress	Not Applicable
General Output	Output Database; Units; Activity	***<MOVES OUTPUT DATABASE NAME>;***[1] grams, Joules, Miles; source hours operating
Output Emissions Detail	Always; For All Vehicles/Equipment; On-Road	Time: Hour – Location: Link – Pollutant; Fuel Type, Emissions Process; Road Type, Source Use Type
Advanced Performance Measures	Aggregation and Data Handling	Not Applicable

1 Project scale allows multiple counties and a single year/month/day-type/hour combination per run (one county was selected per run). Geographic and temporal identifiers were included in the MRS file names and the PDB names, and output database names. One output database was specified for each year to contain the results of the 16 runs (i.e., four hours by four seasons) in each year. One representative county from each TxDOT district was modeled to estimate emission rates representative of the districts.

2 Some of these pollutants require other "base" pollutants (not listed in the table) to be selected in the MRS (e.g., VOC requires Total Gaseous Hydrocarbons and Non-Methane Hydrocarbons; Atmospheric CO2 requires Total Energy Consumption; PM2.5 includes several subcomponents, e.g., elemental carbon, organic carbon, sulfate).

3 DPM is diesel emissions of organic carbon, elemental carbon, and sulfates.

4 POM emissions are estimated using the most predominant POM pollutants, listed below, without NAP: Acenaphthene, Acenaphthylene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3,c,d)pyrene, Phenanthrene, and Pyrene.

STEP 2 – DEVELOPMENT OF MOVES COUNTY SCALE AND PROJECT SCALE INPUT DATABASES

MOVES is designed to require vehicle types, ages, fuel types, and other input parameters to estimate emission rates. Local input parameters were used to develop and produce rates reflective of the local scenario conditions (e.g., weather and fleet characteristics, fuel properties, I/M program where required). TTI developed one set of MOVES county-scale input databases (CDBs) and project-scale input databases (PDBs), each including 16 analysis year input databases (containing seasonal data represented by the months January, April, July, and October), for each of the nine districts (i.e., representative counties). These databases include combinations of database input parameter tables for inputs to MOVES, particular to each model scale (i.e., county and project scale modes). TTI developed these CDBs and PDBs with a standard set of MOVES data tables necessary for conducting local county-scale and project-scale emission rate runs. These runs produced county-scale hourly results and project-scale individual hour results, as specified in the associated MRS files.

Table 5 and Table 6 provide a brief description of the CDB and PDB input tables that TTI used for county-scale and project-scale databases, respectively. TTI developed a total of 288 input databases (CDBs and PDBs combined) for the complete analysis set of county-scale (144 CDBs) and project-scale (144 PDBs) MOVES runs.

Table 5. County Database Input Tables used for County-scale Runs.

MOVES Input Table	Data Category	Notes
year	Time	Designates analysis year as a base year (i.e., activity inputs for the analysis are supplied rather than forecast by the model).
state	Geography	Identifies the state (Texas) for the analysis.
county	Geography/ Meteorology	Specifies county, local altitude, and annual average barometric pressure (2017 average district data provided by TCEQ). See Appendix B – MOVES Meteorological Inputs for Each Season by Area.
zonemonthhour	Meteorology	Local, hourly temperature and relative humidity for the district (2017 spring, summer, fall, and winter periods provided by TCEQ). See Appendix B – MOVES Meteorological Inputs for Each Season by Area.
roadtype[1]	Activity	Lists the MOVES road types and associated ramp activity fractions. Road type ramp fractions were set to 0.
hpmsvtypeyear[2]	Activity	MOVES default national annual VMT by HPMS vehicle type.
roadtypedistribution[2]		MOVES default road type VMT fractions.
monthvmtfraction[2]		MOVES default month VMT fractions.
dayvmtfraction[2]		MOVES default day VMT fractions.
hourvmtfraction[2]		MOVES default hour VMT fractions.
avgspeeddistribution[2]		MOVES default average speed distributions.
sourcetypeyear[2]	Fleet	MOVES default national SUT populations.

MOVES Input Table	Data Category	Notes
sourcetypeage distribution	Fleet	Local SUT age fractions estimated using TxDMV latest available (2018) vehicle registrations and MOVES defaults, as needed. See Appendix C – MOVES Source Type Age Distributions Inputs.
avft	Fleet	Local SUT fuel fractions estimated using TxDMV vehicle registration data (consistent with sourcetypeagedistribution) and defaults where needed—included gasoline and diesel only, consistent with local VMT mix. See Appendix D – MOVES AVFT (fuel engine fractions) Inputs.
zone	Activity	Start, idle, and SHP zone allocation factors. County = zone, and all factors are set to 1.0 (required for county scale analyses).
zoneroadtype	Activity	SHO zone/roadtype allocation factors. County = zone, and all factors are set to 1.0 (required for county scale analyses).
fuelsupply	Fuel	Fuel supply market shares are set to specify one conventional gasoline and one conventional diesel fuel formulation, per applicable fuel region and season.
fuelformulation	Fuel	Local gasoline and diesel formulations prepared by TTI based on EPA RFG survey data and TCEQ gasoline and diesel survey data, and MOVES defaults as needed. Applied summer and winter formulations, as appropriate, in each of the four seasons. See Appendix E – MOVES Fuel Formulation Inputs for Each Season by Area.
imcoverage	I/M	Local I/M program modeling parameters as appropriate (e.g., based on representativeness specific to each district). See Appendix F – MOVES I/M Coverage Inputs.
hotellingactivity distribution	Activity	Used the new updated distribution from TCEQ's 2017 long-haul truck hotelling/idling study. See Appendix G – MOVES Hotelling Activity Distribution Inputs.

1 In MOVES rates mode, separate "ramp road type" rates are not available.

2 Use of a default set of VMT activity, various travel-related factors, and vehicle population inputs for all MOVES runs is basic to the rates development method, e.g., MOVES default activity is normalized in the calculated rates for applicable processes, and actual local activity estimates are used in the external emissions calculations.

Table 6. Project Database Input Tables used for Project-scale Runs.

MOVES Input Table	Data Category	Notes
year	Time	Designates analysis year as a base year (meaning activity inputs for the analysis are supplied rather than forecast by the model).
state	Geography	Identifies the state (Texas) for the analysis.
county	Geography/ Meteorology	Specifies county, local altitude, and annual average barometric pressure (2017 average district data provided by TCEQ). See Appendix B – MOVES Meteorological Inputs for Each Season by Area.
zonemonthhour	Meteorology	Local, hourly temperature and relative humidity for the district (2017 spring, summer, fall, and winter periods provided by TCEQ). See Appendix B – MOVES Meteorological Inputs for Each Season by Area.
Link	Activity	Input road segments (i.e., "links") within the project domain, e.g., highways, ramps, arterials, intersections. Each link was given an average speed of "0" to represent idling activity.
linksourcetypehour	Activity	Allocation of activity by source type. Each source type's activity fraction within the project's single hour on each link was expressed.
driveschedule secondlink	Activity	Input of the second-by-second activity on the link. Not applicable in analysis.
opmodedistribution	Activity	Input of the operating distribution for vehicles during starts mode and running operation on the link. Not applicable in analysis.
offnetworklink	Activity	Input of population and activity fractions for each source type present in the off-network link. Not applicable in analysis.
onroadretrofit	Fleet	Input of retrofit technology used for on-road vehicles. Not applicable in analysis.
sourcetypeage distribution	Fleet	Local SUT age fractions estimated using TxDMV latest available (2018) vehicle registrations and MOVES defaults, as needed. See Appendix C – MOVES Source Type Age Distributions Inputs.
avft	Fleet	Local SUT fuel fractions estimated using TxDMV vehicle registration data, consistent with the sourcetypeagedistributions, and defaults where needed. Included only gasoline and diesel, consistent with local VMT mix. See Appendix D – MOVES AVFT (fuel engine fractions) Inputs.
zone	Activity	Start, idle, and SHP zone allocation factors. County = zone, and all factors are set to 1.0 (required for county scale analyses).
zoneroadtype	Activity	SHO zone/roadtype allocation factors. County = zone, and all factors are set to 1.0 (required for county scale analyses).

MOVES Input Table	Data Category	Notes
fuelsupply	Fuel	Fuel supply market shares are set to specify one conventional gasoline and one diesel fuel formulation, per applicable fuel region and season.
fuelformulation	Fuel	Local gasoline and diesel formulations prepared by TTI based on EPA RFG survey data and TCEQ gasoline and diesel survey data, and MOVES defaults as needed. Applied summer and winter formulations, as appropriate, in each of the four seasons. See Appendix E – MOVES Fuel Formulation Inputs for Each Season by Area.
fuelusagefraction	Fuel	Specifies ethanol fuel (i.e., nominal 85% ethanol and 15% gasoline blend) use for flex-fuel vehicles. Not applicable since avft is set to gasoline and diesel only for this analysis.
imcoverage	I/M	Local I/M program modeling parameters as appropriate (e.g., based on representativeness specific to each district). See Appendix F – MOVES I/M Coverage Inputs
hotellinghours	Activity	Input for hotelling hours for the project. Not applicable in analysis. See Appendix G – MOVES Hotelling Activity Distribution Inputs
hotellingactivity distribution	Activity	Used the new updated distribution from TCEQ's 2017 long-haul truck hotelling/idling study. Not applicable in analysis.

STEP 3 – EXECUTION OF MOVES EMISSION RATE RUNS

After creating RunSpecs and MOVES input databases identified in the previous steps, MOVES runs were conducted for estimating emission rates from both county-scale and project-scale modes. Four RunSpecs and one CDB were required per area/district and analysis year MOVES run for producing running, start, and extended idling emission rates by season using the county-scale run mode. Each county-scale run (by district, year, and season) produced an individual output database. Sixteen RunSpecs (representing the four time-of-day periods in each of the four seasons) and one PDB were required per area/district and analysis year. These sixteen MOVES runs produced idling emission rates using the project-scale run mode. The sixteen project-scale RunSpecs for each district and analysis year were designed to append their results to one MOVES output database (i.e., one output database per 16 runs). Table 7 summarizes the number of MOVES runs that were conducted under this task.

Table 7. MOVES Runs Required and Estimated Run Time.

MOVES Run Type	Areas & Years	RunSpecs (per Area & Year)	Input Databases (per Area & Year)	Total MOVES Runs & Output Databases
County-scale (running, start, extended idling, etc.)	9 & 16	4 (Spring, Summer, Fall, Winter)	1 (with input data for Spring, Summer, Fall, Winter)	576 & 576
Project-scale (idling)	9 & 16	16 (Spring, Summer, Fall, Winter) & (AM Peak, PM Peak, Midday, Overnight)	1 (with input data for Spring, Summer, Fall, Winter and four time-of-day periods)	2,304 & 144

The MOVES model produces results at different aggregation levels that are specified in the MRS. For this analysis, MOVES weekday type rates were produced at the following output detail level:

- 13 source use types (i.e., vehicle types)
- two fuel types
- five road types (four actual MOVES road categories and "off-network")
- Each of the 24 hours in a day (for county scale)
- Each of four hours (one hour each for two peak and two off-peak periods, for project scale)
- Sixteen speed bins (for county scale - only in miles-based rate tables).
- Separate idling bin (for project scale)
- Required pollutants and processes

The vehicle fleet was modeled as powered by the predominant on-road fuels of gasoline and diesel only (alternative fuels are considered de minimis). The five road type categories in MOVES are Rural Restricted Access, Rural Unrestricted Access, Urban Restricted Access, Urban Unrestricted Access, and Off-Network (which is not a road type but a location for parked vehicle activity). The rates for each of the four actual road types are indexed by the 16 MOVES speed bin average speeds: 2.5, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, and 75 mph. The rates were indexed by one speed bin for project-scale runs with an average speed set to 0 mph (for idling).

STEP 4 – CREATION OF VEHICLE TYPE VMT MIXES, HOURLY TRAVEL FACTORS, AND TXLED FACTORS

The vehicle type VMT mix and hourly travel factors are required to aggregate the hourly and vehicle type MOVES emission rate to develop daily composite emission factors. TxLED factors are required to reduce NO_X emissions due to the implementation of TxLED programs in different Texas districts.

Vehicle Type VMT Mix

The VMT mix specifies the fraction of on-road fleet VMT attributable to each vehicle type and MOVES road type. It estimates the fraction of travel attributable to each SUT by fuel type and can be used to estimate the fleet composite emission rates by hour. Since the VMT mix can vary by hour (and thus influence composite emissions rates by hour), a TTI VMT mix procedure was used to develop time period VMT mixes. The time periods for VMT mix are morning rush hour (AM peak), mid-day, evening rush hour (PM peak), and overnight.

TxDOT district-level, time period, weekday (average Monday through Friday) VMT mix (for gasoline- and diesel-powered vehicles) is estimated by the four MOVES road-types using the methodology characterizing VMT by vehicle type for a region or district (*13*).

TxDOT district-level Weekday VMT mixes by MOVES road-type category were produced based on recent multi-year vehicle classification counts (2009 through 2018) and appropriate end-of-year TxDMV vehicle registrations data (latest available, 2018). To ensure general applicability and consistency across all study areas, TTI staff developed all VMT mixes in five-year increments. These were applied to analysis years based on Table 8. Table 9 shows the sample VMT mix by roadway type and MOVES vehicle type, which was updated based on the latest TxDMV and other data. The VMT mixes are included in Appendix H – Time of Day VMT Mixes.

Table 8. VMT Mix Year/Analysis Year Correlations.

VMT Mix Year	Applicable Analysis Year Range
2020	2018 through 2022
2025	2023 through 2027
2030	2028 through 2032
2035	2033 through 2037
2040	2038 through 2042
2045	2043 through 2047
2050	2048 through 2050

13. TTI. MOVES Source Use Type and VMT Mix for Conformity Analysis (TxDOT Air Quality/Conformity IAC-A - TTI Task 409480-0843: Maintain, Update and Enhance Traffic Activity Estimation and Forecasting Methods), Texas Department of Transportation, Austin, TX. October 2017.

Table 9. Sample VMT Mix by Roadway Type.

SUT/FT	AM Peak				Mid-Day				PM Peak				Overnight			
	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]
MC_Gas	0.00069	0.00065	0.00071	0.00079	0.00066	0.00061	0.00067	0.00076	0.00066	0.00066	0.00069	0.00080	0.00071	0.00070	0.00073	0.00080
PC_Gas	0.68921	0.64652	0.70062	0.78703	0.65077	0.60065	0.66036	0.75194	0.65599	0.65506	0.68445	0.79670	0.70020	0.69777	0.72244	0.79673
PC_Diesel	0.00486	0.00456	0.00494	0.00555	0.00459	0.00423	0.00466	0.00530	0.00462	0.00462	0.00482	0.00562	0.00494	0.00492	0.00509	0.00562
PT_Gas	0.16924	0.17863	0.17102	0.13534	0.16672	0.18883	0.17488	0.15245	0.13357	0.15357	0.14758	0.12149	0.15744	0.17654	0.16172	0.13667
PT_Diesel	0.00293	0.00309	0.00296	0.00234	0.00288	0.00327	0.00302	0.00264	0.00231	0.00266	0.00255	0.00210	0.00272	0.00305	0.00280	0.00236
LCT_Gas	0.04153	0.04383	0.04196	0.03321	0.04091	0.04633	0.04291	0.03741	0.03278	0.03768	0.03621	0.02981	0.03863	0.04332	0.03968	0.03354
LCT_Diesel	0.00232	0.00245	0.00235	0.00186	0.00229	0.00259	0.00240	0.00209	0.00183	0.00211	0.00203	0.00167	0.00216	0.00242	0.00222	0.00188
IBus_Diesel	0.00016	0.00025	0.00021	0.00036	0.00020	0.00019	0.00021	0.00025	0.00015	0.00009	0.00014	0.00025	0.00012	0.00010	0.00013	0.00019
TBus_Gas	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TBus_Diesel	0.00032	0.00050	0.00042	0.00071	0.00041	0.00037	0.00042	0.00051	0.00031	0.00017	0.00028	0.00050	0.00023	0.00019	0.00026	0.00039
SBus_Gas	0.00001	0.00001	0.00001	0.00002	0.00001	0.00001	0.00001	0.00001	0.00001	0.00000	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
SBus_Diesel	0.00087	0.00139	0.00114	0.00196	0.00112	0.00102	0.00117	0.00139	0.00084	0.00048	0.00076	0.00137	0.00064	0.00053	0.00071	0.00107
RT_Gas	0.00047	0.00074	0.00050	0.00034	0.00067	0.00094	0.00069	0.00050	0.00042	0.00053	0.00040	0.00028	0.00039	0.00048	0.00038	0.00021
RT_Diesel	0.00069	0.00110	0.00074	0.00051	0.00099	0.00139	0.00102	0.00074	0.00062	0.00079	0.00059	0.00041	0.00059	0.00072	0.00057	0.00031
SUShT_Gas	0.00869	0.01382	0.00931	0.00638	0.01264	0.01772	0.01301	0.00946	0.00852	0.01088	0.00816	0.00565	0.00750	0.00919	0.00724	0.00398
SUShT_Diesel	0.01293	0.02056	0.01384	0.00949	0.01880	0.02636	0.01935	0.01408	0.01267	0.01619	0.01213	0.00841	0.01116	0.01367	0.01077	0.00593
SULhT_Gas	0.00158	0.00252	0.00169	0.00116	0.00206	0.00288	0.00212	0.00154	0.00065	0.00083	0.00062	0.00043	0.00117	0.00143	0.00113	0.00062
SULhT_Diesel	0.00235	0.00374	0.00252	0.00173	0.00306	0.00429	0.00315	0.00229	0.00097	0.00124	0.00093	0.00064	0.00174	0.00213	0.00168	0.00093
MH_Gas	0.00037	0.00058	0.00039	0.00027	0.00052	0.00074	0.00054	0.00039	0.00033	0.00042	0.00031	0.00022	0.00031	0.00038	0.00030	0.00016
MH_Diesel	0.00055	0.00087	0.00058	0.00040	0.00078	0.00109	0.00080	0.00058	0.00049	0.00062	0.00047	0.00032	0.00046	0.00056	0.00044	0.00024
CShT_Gas	0.00364	0.00449	0.00267	0.00064	0.00529	0.00568	0.00404	0.00092	0.00509	0.00398	0.00346	0.00083	0.00378	0.00230	0.00229	0.00046
CShT_Diesel	0.02551	0.03142	0.01867	0.00447	0.03706	0.03977	0.02828	0.00646	0.03560	0.02788	0.02424	0.00584	0.02646	0.01609	0.01602	0.00321
CLhT_Gas	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
CLhT_Diesel	0.03108	0.03828	0.02275	0.00544	0.04757	0.05104	0.03629	0.00829	0.10157	0.07954	0.06917	0.01665	0.03864	0.02350	0.02339	0.00469

1 RT2 - Rural Restricted Access; 2 RT3 – Rural Unrestricted Access; 3 RT4 - Urban Restricted Access; 4 RT5 – Urban Unrestricted Access.

Hourly Travel Factors

Hourly travel factors or hour mixes were used to distribute the travel to each hour of the day. These hourly travel factors were developed using multi-year aggregated automatic traffic recorder (ATR) station data for all study areas. Each factor (i.e., 24, or one for each hour of the day) was multiplied by the hourly emission rate to estimate daily composite emission rates from the county-scale outputs. Table 10 shows the sample hourly travel factors. The hourly factors used for each area are included as Appendix I – Hourly VMT Distributions by Area.

Table 10. Sample Hourly Factors.

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.052965
	8	0.061358
	9	0.057668
Mid-Day	10	0.054863
	11	0.053117
	12	0.055446
	13	0.05719
	14	0.057944
	15	0.059662
	16	0.061844
PM Peak	17	0.06163
	18	0.061642
	19	0.058603
Overnight	20	0.049941
	21	0.040588
	22	0.03543
	23	0.028022
	24	0.019985
	1	0.012212
	2	0.008652
	3	0.008061
	4	0.007098
	5	0.010124
	6	0.025953

*Note: Hour ID 1 is 12-1 a.m., etc.

TxLED Factors

TxLED fuel, implemented in October 2005, conforms to federal diesel sulfur standards but changes other properties of the conventional diesel (including increasing the cetane number and lowering aromatic hydrocarbon [HC] content). Texas implemented these changes in diesel specifications to reduce emissions of nitrogen oxides by an estimated 4.8 percent up to 6.2

percent from diesel-powered motor vehicles and nonroad equipment in 110 counties in the eastern half of Texas, as a part of the plan to control ozone air pollution. Under the rule, diesel is supplied in 110 counties, including the Houston-Galveston-Brazoria, Beaumont-Port Arthur, and Dallas-Fort Worth ozone nonattainment or maintenance area counties must comply with the TxLED requirements. Table 11 shows the TxLED factor by vehicle types and analysis year.

Table 11. TxLED Factors by SUT Type and Analysis Year.

Analysis Year	SUT ID											
	21	31	32	41	42	43	51	52	53	54	61	62
2020	0.9496	0.9489	0.9460	0.9436	0.9444	0.9440	0.9474	0.9509	0.9508	0.9469	0.9493	0.9490
2022	0.9504	0.9496	0.9470	0.9446	0.9454	0.9449	0.9484	0.9512	0.9512	0.9478	0.9500	0.9498
2024	0.9512	0.9504	0.9480	0.9455	0.9464	0.9459	0.9495	0.9516	0.9515	0.9487	0.9507	0.9507
2026	0.9517	0.9510	0.9490	0.9469	0.9476	0.9472	0.9503	0.9518	0.9517	0.9495	0.9511	0.9512
2028	0.9518	0.9513	0.9500	0.9486	0.9491	0.9488	0.9509	0.9519	0.9518	0.9503	0.9514	0.9515
2030	0.9519	0.9517	0.9510	0.9503	0.9505	0.9504	0.9514	0.9519	0.9519	0.9512	0.9517	0.9517
2032	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2034	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2036	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2038	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2040	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2042	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2044	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2046	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2048	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520
2050	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520	0.9520

STEP 5 – ESTIMATION OF COMPOSITE EMISSION FACTORS

TTI used the emission rates, VMT mix, hour mix, and TxLED factors from the previous step to develop composite emission factors. In addition to these mixes, the analysis incorporated MOVES output hourly activity distribution, MOVES output starts per vehicle distribution, and the MOVES default hotelling distribution. The following four sub-sections describe the composite emission factor estimations for running, starts, extended idling, and idling processes for individual scenarios. A scenario comprises a unique district, year, and month combination. For instance, the El Paso district results for the year 2020 and January month would form one scenario.

Running Composite Emission Factors

The running composite emission rate development used the MOVES rates per distance output tables from the county level runs. This table provides emission rates (grams per miles) output for all the pollutants, running processes, road types, vehicle types, and fuel type combinations specified in the MOVES RunSpecs file. Pre-processing involved filtering to only keep criteria pollutants and MSAT, filtering out refueling processes (refueling displacement vapor loss and spillage loss). Moreover, summing emission rates over running processes by the hour (each of 24 hours in a day), road type (4 road types), source and fuel type combinations (22 combinations), and MOVES average speed bins (16 bins) for each scenario. The following equation describes the above aggregation step:

$$ER_{running,p,d,y,m,r,s,h,v,f} = \sum_{i} ER_{running,p,d,y,m,r,s,h,v,f,i}$$

Where

p = Pollutant listed in Criteria and MSAT list.

d = Analysis scenario district selected from the nine districts included in this study.

y = Analysis scenario year; $y \in \{2020, 2022, 2024 \ldots, 2048, 2050\}$.

m = Analysis scenario month; $m \in \{January, April, July, October\}$.

r = Road type; $r \in \{Rural\ Restricted\ Access,\ Rural\ Unrestricted\ Access,$ $Urban\ Restricted\ Access,\ Urban\ Unrestricted\ Access\}$.

s = Average speed bin from the 16 MOVES average bins between speeds 0 and 75 mph.

h = Hours of the day; $h \in \{Midnight - 1\ am, 1 - 2\ am, 2 - 3\ am, \ldots, 23 - Midnight\}$.

v, f = Vehicle type and fuel types combinations from the list of vehicle and fuel types selected in MOVES RunSpec.

i = Processes; $i \in \{Running\ exhaust,\ crankcase\ running\ exhaust,\ brakewear,\ tirewear,$ $Evap\ Permeation,\ Evap\ Fuel\ Vapor\ Venting,\ and\ Evap\ Fuel\ Leaks\}$.

$ER_{running,p,d,y,m,r,s,h,v,f,i}$ = Running processes emission rates for a scenario by road type, average speed bin, hour of the day, vehicle and fuel type combination, and different running processes.

$ER_{running,p,d,y,m,r,s,h,v,f}$ = Running processes emission rates for a scenario by road type, average speed bin, the hour of the day, vehicle, and fuel type combination.

Hour mix table for the scenario district from Step 4 was then applied to the above-aggregated emission rate table to factor the hourly variation in the VMT into the emission rates.

In addition to the Hour mix table, the analysis uses VMT distribution/ mix of the source and fuel type combinations (22 combinations) for four periods of the day (AM peak, midday, PM peak, and overnight) and the four road types. The VMT mix table changes by the scenario district and year grouping (Table 8). It is applied to the aggregated emission rate table to factor the vehicle and fuel type variation in the VMT during different hours/ periods of the day and different road types.

TxLED factors by vehicle type for the scenario year are then applied to NO_X and NO_2 emission rates to reduce emissions due to the TxLED program. TxLED factors are only applied to diesel vehicles and districts that have an operational TxLED program.

The composite emission factors for a scenario are then obtained by aggregating the emission rates factored by hour mix, periodic/ hourly modal (and fuel type) mix, and TxLED factors over the hours and vehicle-fuel type combinations. This provides the composite emission rates for different road types and MOVES average speed bins for a scenario. The following equation shows the various components of composite emission factors development:

$$ER_{running,p,d,y,m,r,s} = \sum_{h,v,f} ER_{running,p,d,y,m,r,s,h,v,f} * HourMix_{d,h} * VMTMix_{d,y,h,r,h,v,f} * TxLED_{d,y,p,v,f}$$

Where

$HourMix_{d,h} = District\ d\ \ Hour\ h\ VMT/$District d Daily VMT; Converts daily VMT to hourly VMT for district *d*.

$VMTMix_{d,y,h,r,h,v,f} = \frac{\text{District d,year y,road type r vehicle type,and fuel types combination } v,f \text{ VMT during hour } h}{\text{District d,year y,road type r,and hour } h \text{ VMT}}$;
Converts hourly VMT into hourly vehicle type, fuel type-specific VMT for district *d*, analysis year *y*, and road type *r*.

$TxLED_{d,y,p,v,f}$ = TxLED factor for the vehicle type, fuel type combination for the analysis year. TxLED factor is one (no effect on emission rates) for all gasoline vehicles and all pollutants except NO_X and NO_2. TxLED factors are not applied to El Paso district scenarios as El Paso does not have a TxLED program.

$ER_{running,p,d,y,m,r,s}$ = Composite running emission factors for a scenario by road type and average speed bin.

The above methodology provided the composite emission factors for the 16 analysis years and 16 MOVES average speed bins. TTI staff used linear interpolation to obtain the emission rates for 14 years between the 16 analysis years. Moreover, per EPA guidance, the inverse of average speeds from the 16 MOVES speed bin was used to interpolate the composite emission rates for different speeds within the speed bins. The interpolation output provided composite emission factors for 30 years between 2020 and 2050; 2.5 mph speed; and speeds in 1 mph increments between 3 and 75 mph.

TTI staff then used a conservative approach by taking the maximum seasonal composite emission factors within different districts, years, road type, and speed groups as the average composite emission factor for that district, year, road type, and speed group. Table 12 shows sample running composite emission rates. The following equation shows the above aggregation:

$$ER_{running,p,d,y,r,s} = \max_{m} ER_{running,p,d,y,m,r,s}$$

$ER_{running,p,d,y,m,r,s}$ = Composite running emission factors for district *d* and year *y* by road type and average speeds.

Where

y = Analysis scenario year; $y \in \{2020, 2021, 2022 \dots, 2049, 2050\}$.

s = Average speeds in mph; $s \in \{2.5, 3, 4, 5, 6, \dots 73, 74, 75\}$.

All other indices are the same as defined previously.

Table 12. Sample Running Composite Emission Rates (grams/mile).

Area	Year	Road Description	Average Speed	CO	NO_X	SO_2	NO_2
Austin	2020	Rural Unrestricted Access	2.5	9.287	2.174	0.018	0.416
Austin	2020	Rural Unrestricted Access	3	8.211	1.845	0.015	0.352
Austin	2020	Rural Unrestricted Access	4	6.866	1.434	0.012	0.272
Austin	2020	Rural Unrestricted Access	5	6.060	1.188	0.010	0.224
Austin	2020	Rural Unrestricted Access	6	5.520	1.046	0.009	0.196
Austin	2020	Rural Unrestricted Access	7	5.135	0.946	0.008	0.177
Austin	2020	Rural Unrestricted Access	8	4.846	0.870	0.007	0.162
Austin	2020	Rural Unrestricted Access	9	4.621	0.811	0.006	0.150
Austin	2020	Rural Unrestricted Access	10	4.441	0.764	0.006	0.141

Area	Year	Road Description	Average Speed	CO	NO_X	SO_2	NO_2
Austin	2020	Rural Unrestricted Access	11	4.298	0.731	0.006	0.135
Austin	2020	Rural Unrestricted Access	12	4.179	0.703	0.005	0.129
Austin	2020	Rural Unrestricted Access	13	4.078	0.680	0.005	0.125
Austin	2020	Rural Unrestricted Access	14	3.992	0.660	0.005	0.121

Starts Composite Emission Factors

The starts composite emission factors development used the MOVES rates per starts output tables from the county level runs. This output table provides emission rates per start for all the pollutants, start processes, vehicle types, and fuel type combinations specified in the MOVES RunSpecs file. Similar to running composite rate development, pre-processing involved filtering only to keep criteria pollutants and MSAT. Moreover, emission rates are summed over start processes (start and crankcase start exhaust) by the hour (each of 24 hours in a day) and source and fuel type combinations (22 combinations) for each scenario. The following equation describes the above aggregation step:

$$ER_{starts,p,d,y,m,h,v,f} = \sum_{i} ER_{starts,p,d,y,m,h,v,f,i}$$

Where

p, *d*, *y*, *m*, *h*, *v*, *f* are the same as the indices defined under running emission rate pre-processing.

i = Processes; $i \in \{Start\ exhaust, crankcase\ start\ \ exhaust\}$.

Next, the hourly distribution of daily starts is applied to the above-aggregated emission rate table to factor the hourly variation in daily starts for different vehicle-fuel types in the emission rates. The hour mix table's function for starts is similar to the hour mix function in the running composite emission rate development. Hourly start mix factors were developed from the starts per vehicle table present in the MOVES output database. Starts per vehicle table provide the number of starts per vehicle for different vehicle-fuel type combinations during different hours of the day. For each vehicle-fuel type combination, starts per vehicle distribution over the different hours of the day was normalized to obtain a distribution of starts (hourly starts/ daily starts) during different hours of the day. This hourly start mix allows daily starts by different vehicle-fuel type combinations to be converted into hourly starts by different vehicle-fuel combinations before getting applied to the emission rates.

Next, TTI staff incorporated the effect of the TxLED program on emission rates. TxLED factor application follows the same procedure as described under the running composite rate section.

The composite emission factors for a scenario are then obtained by aggregating the emission rates factored by hourly start mix and TxLED factors over the hours. This provides the composite emission rates for different vehicle-fuel type combinations for a scenario. The following equation shows the various components of composite rate development:

$$ER_{starts,p,d,y,m,v,f} = \sum_{h,v,f} ER_{starts,p,d,y,m,h,v,f} * StartsHourMix_{d,y,m,h,v,f} * TxLED_{d,y,p,v,f}$$

Where

$StartsHourMix_{d,y,m,h,v,f} = \frac{Hour\ h\ starts\ for\ vehicle\ type\ v, fuel\ type\ f\ for\ a\ scenario}{Daily\ starts\ for\ vehicle\ type\ v, fuel\ type\ f\ for\ a\ scenario}$; Converts daily start for vehicle and fuel type to hourly starts for that vehicle and fuel type.

$ER_{starts,p,d,y,m,v,f} = =$ Composite start emission factors for the scenario by vehicle and fuel type.

The above methodology provided the composite factors for the 16 analysis years. TTI staff used linear interpolation to obtain the emission rates for years between the 16 analysis years. Interpolation output provided composite emission rates for 30 years between 2020 and 2050. TTI staff then used a conservative approach by taking the maximum seasonal composite emission factor within different districts, years, and vehicle and fuel type groups as the average composite emission factor for that district, year, and vehicle and fuel type group. Table 13 shows sample start composite emission rates. The following equation shows the above aggregation:

$$ER_{starts,p,d,y,v,f} = \max_{m} ER_{starts,p,d,y,m,v,f}$$

Where

$ER_{starts,p,d,y,v,f}$ = Composite starts emission rates for the scenario by vehicle and fuel type.

y = Analysis scenario year; $y \in \{2020, 2021, 2022 \ldots, 2049, 2050\}$.

All other indices are the same as defined previously.

Table 13. Sample Start Composite Emission Rates (grams/start).

Area	Year	Vehicle Type	Fuel Type	CO	NO_X	SO_2	NO_2
Austin	2020	Combination Long-haul Truck	Diesel	5.782	0.000	0.0006	0.000
Austin	2020	Combination Short-haul Truck	Diesel	4.274	0.000	0.0004	0.000
Austin	2020	Combination Short-haul Truck	Gasoline	95.514	1.374	0.0008	0.040
Austin	2020	Intercity Bus	Diesel	6.775	0.280	0.0008	0.068
Austin	2020	Light Commercial Truck	Diesel	4.554	1.067	0.0007	0.211
Austin	2020	Light Commercial Truck	Gasoline	12.131	1.124	0.0008	0.040
Austin	2020	Motor Home	Diesel	3.931	0.951	0.0010	0.272
Austin	2020	Motor Home	Gasoline	183.890	2.851	0.0015	0.079

Area	Year	Vehicle Type	Fuel Type	CO	NO_X	SO_2	NO_2
Austin	2020	Motorcycle	Gasoline	4.635	0.178	0.0006	0.002
Austin	2020	Passenger Car	Diesel	4.560	0.241	0.0005	0.071
Austin	2020	Passenger Car	Gasoline	5.384	0.415	0.0006	0.016
Austin	2020	Passenger Truck	Diesel	4.339	1.142	0.0007	0.251
Austin	2020	Passenger Truck	Gasoline	10.694	1.060	0.0008	0.038

Extended Idling Composite Emission Factors

The composite extended idling emission rates are only developed for diesel combination long-haul trucks. The rate development used the MOVES rates per hour output tables from the county level runs. This table provides emission rates per hour output for all the pollutants specified in the MOVES RunSpecs file and different extended idling processes. Similar to running composite rate development, pre-processing involved filtering to keep criteria pollutants and MSAT from a list of pollutants, and combination long-haul diesel trucks from different vehicle and fuel types. Emission rates are grouped by extended idling processes (extended exhaust and auxiliary power exhaust) by the hour (each of 24 hours in a day) for each scenario. Extended exhaust emission rates include summed emission rates for extended idle exhaust and crankcase idle exhaust processes. The following variable describes the composite extended idling emission rate development:

$$ER_{extnidle,p,d,y,m,h,v=CLhT,f=diesel,j}$$

Where

p, d, y, m, h are the same as the indices defined under running emission rate pre-processing.

v, f = Vehicle type and fuel types combinations. The composite extended idling emission rates are only developed for diesel combination long-haul trucks.

j = Type of extended idling; $j \in \{Extended\ exhaust\ (crankcase\ and\ extended\ idle\ exhaust\ processes),\ auxiliary\ power\ exhaust\}$.

Next, the hotelling hour mix or the hourly distribution of hotelling activity is applied to the above-aggregated emission rate table to factor the hourly variation in daily hotelling activity. Hotelling activity distribution is similar to the hour VMT mix and hourly start mix distribution used in the running and starts composite emission rate estimation. For extended idling, the hotelling hour mix distributes the daily hotelling activity to hourly hotelling activity.

Next, TTI staff incorporated the effect of the TxLED program on emission rates. TxLED factor application follows the same procedure as described under the running composite factor section.

The composite emission rates for a scenario are then obtained by aggregating the emission rates factored by hotelling hour mix and TxLED factors over the hours. This provides the composite emission rates for extended exhaust and APU for a scenario. The following equation shows the various components of composite rate development:

$$ER_{extnidle,p,d,y,m,v=CLhT,f=diesel,j} = \sum_{h} ER_{extnidle,p,d,y,m,h,v=CLhT,f=diesel,j} * HotellingHourMix_h * TxLED_{d,y,p,v=CLhT,f=diesel}$$

Where

$HotellingHourMix_h = \frac{Hour\ h\ hotelling\ activity}{Daily\ hotelling\ activity}$; Converts daily hotelling activity to hourly hotelling activity.

$ER_{extnidle,p,d,y,m,v=CLhT,f=diesel,j}$ = Composite extended emission factors for scenario *d,y,m* by extended idling process type (extended exhaust and APU).

The composite emission factors are interpolated for odd years that were not modeled in MOVES. TTI staff then used a conservative approach by taking the maximum seasonal composite emission rate within different districts, years, and extended idling process type groups as the annual average composite emission factor for that district, year, and extended idling process type group. This approach is similar to the interpolation and aggregation approach described for running and start composite emission rate development. Table 14 shows sample extended idling composite emission rates. The following equation shows the above aggregation:

$$ER_{extnidle,p,d,y,v=CLhT,f=diesel,j} = \max_{m} ER_{extnidle,p,d,y,m,v=CLhT,f=diesel,j}$$

Where

$ER_{extnidle,p,d,y,v=CLhT,f=diesel,j}$ = Composite extended idling emission rates for a scenario district *d* and year *y* by extended idling process type.

y = Analysis scenario year; $y \in \{2020, 2021, 2022 \dots, 2049, 2050\}$.

All other indices are the same as defined previously.

Table 14. Sample Extended Idling Composite Emission Rates (grams/hour).

Area	Year	Process Type	CO	NO_X	SO_2	NO_2
Austin	2020	APU	36.000	27.469	0.013	1.566
Austin	2020	Extnd_Exhaust	89.264	204.657	0.055	65.979
Austin	2021	APU	36.000	27.481	0.013	1.566
Austin	2021	Extnd_Exhaust	89.272	204.332	0.055	68.118
Austin	2022	APU	36.000	27.494	0.013	1.567
Austin	2022	Extnd_Exhaust	89.279	204.007	0.055	70.257
Austin	2023	APU	36.000	27.506	0.013	1.568
Austin	2023	Extnd_Exhaust	89.256	203.824	0.055	71.805
Austin	2024	APU	36.000	27.518	0.013	1.569
Austin	2024	Extnd_Exhaust	89.233	203.641	0.055	73.353
Austin	2025	APU	36.000	27.526	0.013	1.569
Austin	2025	Extnd_Exhaust	89.210	203.304	0.055	74.291
Austin	2026	APU	36.000	27.534	0.013	1.569

Idling Composite Emission Factors

Idling composite emission factors were developed using the MOVES activity output and MOVES output table from the project level runs. MOVES output table provides the total emission quantity for all the pollutants, running processes, road types, vehicle types, and fuel type combinations specified in the MOVES RunSpecs file. All emissions are considered idling emission as the average link speed is set to 0 mph in the project-level input databases. Pre-processing involved summing emission rates over emission processes (running and crankcase running exhaust) by the hour; the four hours modeled for the project-level scenarios, and source and fuel type combinations (22 combinations)) for each scenario. the MOVES activity output table provided the source hour operation (SHO) activity for each vehicle-fuel type combination which was then used to convert the emission into emission rates.

Next, the analysis factors the VMT distribution/ mix of the source and fuel type combinations (22 combinations) for four periods of the day (AM peak, midday, PM peak, and overnight) for urban-unrestricted road types. Urban-unrestricted road type VMT mix is used in the development of composite idling emission factors. The VMT mix table changes by the scenario district and year group. It is applied to the aggregated emission rate table to factor the vehicle-fuel type variation in the VMT during different hours/ periods of the day.

Next, TTI staff incorporated the effect of the TxLED program on emission rates. TxLED factor application follows the same procedure as described under the running composite factor section.

The composite emission factors for a scenario are then obtained by aggregating the emission rates factored by VMT Mix and TxLED factors over the vehicle-fuel type combinations. This aggregation provides the composite emission factors for the four hours modeled in the project-level scenario. The following equation shows the various components of composite rate development:

$$ER_{idling,p,d,y,m,h} = \sum_{h,v,f} ER_{idling,p,d,y,m,h,v,f} * VMTMix_{d,y,h,r=urban-unrestricted,h,v,f} * TxLED_{d,y,p,v,f}$$

Where

p, *d*, *y*, *m*, *h*, *v*, *f* are the same as the indices defined under running emission rate pre-processing.

$VMTMiix_{d,y,h,r=urban-unrestricted,h,v,f}$ = provides the vehicle-fuel combination type splits during the four modeled hours for urban-unrestricted roads.

$ER_{idling,p,d,y,m,h}$ = Composite idling emission factors for a scenario for the four modeled hours (8 am: AM peak, 3 pm: mid-day, 6 pm: PM peak, 11 pm: overnight).

The composite factors are interpolated for odd years that were not modeled in MOVES. TTI staff then used a conservative approach by taking the maximum seasonal and hourly composite emission rate within different districts and year groups as the average composite emission factors for that district and year group. This approach is similar to the interpolation and aggregation approach described for running, starts, and extended idling composite emission rate development. Table 15 shows sample idling composite emission rates. The following equation shows the above aggregation:

$$ER_{idling,p,d,y} = \max_{m,h} ER_{idling,p,d,y,m,h}$$

Where

$ER_{idling,p,d,y}$ = Composite extended idling emission rates for a scenario district *d* and year *y*.

y = Analysis scenario year; $y \in \{2020, 2021, 2022 \ldots, 2049, 2050\}$.

Table 15. Sample Idling Composite Emission Rates (grams/hour).

Area	Year	CO	NO_X	SO_2	NO_2
Austin	2020	6.444	3.280	0.028	0.402
Austin	2021	5.642	2.892	0.027	0.371
Austin	2022	4.841	2.504	0.026	0.340
Austin	2023	4.368	2.208	0.026	0.315
Austin	2024	3.896	1.912	0.025	0.291
Austin	2025	3.173	1.695	0.024	0.285
Austin	2026	2.456	1.478	0.023	0.278
Austin	2027	2.289	1.315	0.023	0.265
Austin	2028	2.123	1.151	0.022	0.251
Austin	2029	1.947	1.051	0.022	0.240
Austin	2030	1.771	0.951	0.021	0.228
Austin	2031	1.390	0.836	0.021	0.214
Austin	2032	1.009	0.720	0.020	0.199

Summary

Running, start, extended idling, and idling composite factors, in the form of ERLTs for the various pollutants, years, and other relevant groupings such as roadway type, speeds, and process type are provided in MS-Excel® spreadsheet format as the final output of this project, along with the necessary supporting documentation. Table 12, Table 13, Table 14, and Table 15 show a sample from the final output. See Appendix A – MOVES Pollutants Modeled for the complete list of MOVES pollutants modeled and aggregations used in the ERLTs.

APPENDIX A – MOVES POLLUTANTS MODELED

A.1. Pollutants Included in Emission Rate Lookup Tables

MOVES Pollutant ID	MOVES Pollutant Name	Aggregate Pollutant
Criteria Pollutants, Precursors of Criteria Pollutants, and Greenhous Gas Pollutants		
2	Carbon Monoxide (CO)	CO
3	Oxides of Nitrogen (NO_X)	NO_X
31	Sulfur Dioxide (SO_2)	SO_2
33	Nitrogen Dioxide (NO_2)	NO_2
87	Volatile Organic Compounds (VOC)	VOC
90	Atmospheric CO_2	CO_2
100	Primary Exhaust PM_{10} – Total	PM_{10}
106	Primary PM_{10} –Brakewear Particulate	
107	Primary PM_{10} – Tirewear Particulate	
110	Primary Exhaust $PM_{2.5}$ – Total	$PM_{2.5}$
116	Primary $PM_{2.5}$ – Brakewear Particulate	
117	Primary $PM_{2.5}$ – Tirewear Particulate	
MSAT Pollutants		
111	Organic Carbon	Diesel PM (from diesel vehicle exhaust only)
112	Elemental Carbon	
115	Sulfate Particulate	
20	Benzene	Benzene
24	1,3-Butadiene	1,3-Butadiene
25	Formaldehyde	Formaldehyde
26	Acetaldehyde	Acetaldehyde
27	Acrolein	Acrolein
41	Ethyl Benzene	Ethyl Benzene

MOVES Pollutant ID		MOVES Pollutant Name	Aggregate Pollutant
Gas	PM		
185	23	Naphthalene	Naphthalene
170	70	Acenaphthene	POM
171	71	Acenaphthylene	
172	72	Anthracene	
173	73	Benz(a)anthracene	
174	74	Benzo(a)pyrene	
175	75	Benzo(b)fluoranthene	
176	76	Benzo(g,h,i)perylene	
177	77	Benzo(k)fluoranthene	
178	78	Chrysene	
168	68	Dibenzo(a,h)anthracene	
169	69	Fluoranthene	
181	81	Fluorene	
182	82	Indeno(1,2,3,c,d)pyrene	
185	23	Naphthalene	
183	83	Phenanthrene	
184	84	Pyrene	

APPENDIX B – MOVES METEOROLOGICAL INPUTS FOR EACH SEASON BY AREA

B.1. Meteorological Inputs to MOVES for the Austin District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	65.28	78.23	65.81	51.79	76.49	74.79	77.07	77.55
2	64.39	77.10	65.17	51.29	78.85	78.30	79.25	78.47
3	63.53	76.15	64.43	50.79	80.80	81.18	80.72	79.38
4	62.89	75.38	63.79	50.27	82.32	83.57	81.84	80.15
5	62.38	74.73	63.23	49.82	83.42	85.53	82.89	80.48
6	61.91	74.20	62.63	49.45	84.56	86.99	83.87	80.71
7	61.56	73.77	62.15	49.24	85.08	88.24	84.74	80.85
8	61.84	74.38	61.86	49.31	84.68	87.66	85.18	80.75
9	63.62	76.91	63.43	51.11	81.79	81.80	82.64	77.75
10	66.29	79.75	66.74	54.30	75.36	73.33	75.81	70.80
11	68.90	82.70	70.21	57.55	68.70	65.08	67.37	63.84
12	71.32	85.23	73.25	60.39	62.66	58.64	60.04	58.43
13	73.64	87.42	75.70	62.57	57.07	53.35	54.52	53.89
14	75.58	89.25	77.63	64.25	53.35	49.07	50.43	51.08
15	77.12	90.69	78.94	65.38	50.42	45.73	47.78	49.46
16	78.18	91.54	79.77	65.86	48.69	44.02	45.82	48.66
17	78.59	91.84	79.97	65.20	48.00	43.26	45.35	49.73
18	78.18	91.38	79.11	63.14	48.42	43.99	46.76	53.99
19	76.77	90.34	76.80	59.73	50.55	45.88	50.87	60.41
20	74.32	88.37	73.41	57.28	54.68	49.39	58.02	65.71
21	71.22	85.30	70.81	55.61	61.47	55.83	64.05	69.34
22	69.07	82.73	69.15	54.31	66.69	61.96	68.31	72.74
23	67.59	81.00	67.80	53.36	70.33	66.54	71.65	74.45
24	66.34	79.55	66.74	52.49	73.48	70.82	74.59	76.48

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.2. Meteorological Inputs to MOVES for the Beaumont District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	67.69	78.92	67.70	57.28	87.64	91.60	89.10	86.85
2	67.20	78.55	67.31	56.91	88.52	92.65	89.71	87.10
3	66.72	78.19	66.73	56.55	89.08	93.55	90.52	87.54
4	66.34	77.90	66.24	56.28	89.33	94.15	91.06	87.54
5	65.99	77.61	65.78	56.06	89.58	94.45	91.33	87.36
6	65.70	77.35	65.35	55.85	89.88	94.84	91.88	87.79
7	65.47	77.20	64.98	55.62	90.03	94.89	92.34	88.09
8	66.02	78.01	64.85	55.85	89.07	93.82	92.61	87.74
9	68.07	80.13	66.45	57.73	85.07	89.34	90.06	84.81
10	70.43	82.17	69.74	60.31	77.91	82.01	81.83	79.09
11	72.44	83.81	72.92	62.63	70.77	75.71	71.84	72.25
12	74.11	84.96	75.27	64.40	65.37	71.26	64.14	67.27
13	75.44	85.68	76.96	65.73	61.44	68.68	58.94	63.53
14	76.28	85.81	78.10	66.80	59.12	67.60	55.58	60.85
15	76.80	85.99	78.72	67.28	57.78	67.16	53.93	59.72
16	77.03	86.11	78.99	67.01	57.46	67.47	53.20	60.11
17	76.76	86.16	78.68	65.82	57.92	67.84	54.47	62.81
18	76.02	85.67	77.55	63.71	59.28	69.22	57.53	69.47
19	74.65	84.85	75.04	61.39	62.63	71.64	66.44	76.82
20	72.54	83.42	72.24	60.17	69.21	75.96	77.02	80.61
21	70.55	81.49	70.56	59.36	77.43	82.56	82.48	82.84
22	69.49	80.37	69.62	58.71	81.65	86.81	85.29	84.21
23	68.77	79.74	68.92	58.18	84.21	88.95	87.02	85.09
24	68.16	79.32	68.29	57.69	86.20	90.31	88.22	85.94

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.3. Meteorological Inputs to MOVES for the Corpus Christi District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	71.51	81.13	72.20	60.61	84.77	85.62	83.33	84.39
2	70.95	80.60	71.70	60.12	85.63	86.90	84.68	85.29
3	70.50	80.06	70.98	59.64	86.35	87.69	85.87	86.24
4	70.06	79.54	70.27	59.20	86.68	88.65	87.04	86.87
5	69.67	79.12	69.70	58.80	87.43	89.49	87.98	87.29
6	69.34	78.71	69.25	58.48	87.92	90.12	88.46	87.42
7	69.08	78.35	68.81	58.08	87.96	90.55	89.08	87.67
8	69.50	79.29	68.75	58.13	87.17	88.60	89.20	87.43
9	71.36	81.90	70.62	59.94	83.01	81.55	84.80	84.06
10	73.73	84.45	73.88	62.85	76.63	73.73	76.11	77.81
11	75.96	86.56	76.90	65.81	69.87	65.99	67.52	71.11
12	77.83	88.32	79.27	68.11	64.61	60.80	60.18	65.20
13	79.23	89.50	80.84	69.88	61.06	57.74	55.82	61.01
14	80.21	90.27	81.83	71.08	58.91	55.98	52.93	58.47
15	80.74	90.72	82.34	71.56	58.11	55.29	51.79	57.76
16	80.96	90.70	82.42	71.44	58.10	55.50	52.11	58.37
17	80.67	90.28	81.89	70.45	59.15	56.91	53.84	60.94
18	79.68	89.36	80.71	68.26	61.60	59.38	57.45	66.69
19	78.11	87.93	78.53	65.72	65.48	62.82	63.63	72.92
20	75.98	85.98	76.42	64.08	71.09	67.92	69.66	77.24
21	74.14	84.02	75.12	63.03	76.73	74.17	74.33	80.18
22	73.15	82.89	74.24	62.28	80.34	78.77	77.74	81.51
23	72.57	82.25	73.53	61.78	82.06	81.61	80.18	82.41
24	72.11	81.62	72.83	61.14	83.62	83.94	81.99	83.33

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.4. Meteorological Inputs to MOVES for the Dallas District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	64.95	78.79	65.15	50.14	73.07	78.02	70.08	71.18
2	63.83	77.93	64.41	49.55	75.54	80.30	72.38	72.15
3	62.91	77.13	63.49	49.01	77.74	82.18	74.51	73.07
4	62.07	76.41	62.64	48.47	79.79	84.04	76.40	74.14
5	61.44	75.83	61.88	47.89	81.62	85.48	78.21	75.24
6	60.86	75.27	61.22	47.33	83.09	86.75	80.00	76.28
7	60.36	74.85	60.67	46.84	83.99	87.81	81.34	77.12
8	60.75	75.55	60.51	46.82	83.29	86.26	82.04	77.31
9	62.65	77.52	62.19	48.58	78.97	81.08	78.42	73.84
10	65.25	79.85	65.53	51.34	72.68	74.66	70.45	68.04
11	67.84	82.14	68.90	54.07	66.15	68.61	62.21	62.45
12	70.17	84.20	71.74	56.44	60.59	63.73	55.32	58.11
13	72.11	86.04	74.10	58.32	56.51	59.65	50.09	54.47
14	73.65	87.58	75.95	59.83	53.57	56.31	46.28	51.93
15	74.92	88.64	77.29	60.92	51.36	53.97	43.79	49.85
16	75.85	89.22	78.15	61.43	49.88	52.54	42.08	49.22
17	76.24	89.35	78.37	61.09	49.14	52.17	41.65	49.98
18	76.07	89.01	77.61	59.38	49.30	52.94	43.08	53.35
19	75.06	88.18	75.38	56.70	51.07	54.88	47.46	58.15
20	72.95	86.50	72.53	55.01	55.73	58.96	53.39	61.41
21	70.47	84.06	70.42	53.76	61.03	64.98	57.90	63.76
22	68.71	82.19	68.86	52.82	65.02	69.67	61.25	65.66
23	67.34	80.87	67.54	51.87	67.83	72.93	64.33	67.55
24	66.07	79.75	66.29	51.04	70.61	75.63	67.27	69.41

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.5. Meteorological Inputs to MOVES for the El Paso District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	68.14	79.77	67.20	48.57	23.03	42.73	38.50	45.01
2	66.23	78.51	65.96	47.44	24.83	45.05	40.84	46.81
3	64.60	77.31	64.78	46.44	26.62	47.11	43.05	48.65
4	63.04	76.27	63.68	45.46	28.48	49.05	44.98	50.32
5	61.69	75.38	62.57	44.62	29.99	50.63	47.16	51.63
6	60.49	74.47	61.65	43.71	31.44	52.45	48.86	53.29
7	59.51	73.96	60.84	43.08	32.34	53.51	49.99	54.26
8	59.95	75.19	60.64	43.39	31.88	51.26	49.70	52.85
9	62.34	77.54	62.64	45.76	29.47	46.95	46.01	48.11
10	65.52	80.13	65.76	48.91	26.28	42.42	41.60	43.16
11	68.95	82.81	69.16	52.31	23.00	37.98	36.84	38.25
12	72.09	85.38	72.17	55.29	19.94	33.88	32.86	34.22
13	74.61	87.54	74.81	57.39	17.74	30.66	29.40	31.80
14	76.65	89.27	76.94	59.07	15.89	28.03	26.63	29.61
15	78.31	90.68	78.53	60.29	14.26	25.90	24.74	27.94
16	79.62	91.85	79.83	60.83	13.17	24.01	22.99	27.40
17	80.42	92.09	80.37	60.37	12.39	24.18	22.34	28.06
18	80.58	91.62	79.89	58.77	12.01	24.77	22.59	30.20
19	79.85	90.74	78.10	56.88	12.50	25.75	24.40	32.70
20	77.98	89.02	75.75	55.16	13.92	28.24	27.18	35.17
21	75.72	86.68	73.61	53.66	15.75	32.05	30.05	37.07
22	73.52	84.78	71.87	52.16	17.73	34.61	32.21	39.26
23	71.62	82.97	70.31	50.77	19.55	37.00	34.13	41.34
24	69.82	81.28	68.69	49.58	21.23	40.04	36.25	42.97

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.6. Meteorological Inputs to MOVES for the Fort Worth District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	64.40	78.54	64.56	48.85	70.70	74.20	68.59	68.14
2	63.30	77.62	63.71	48.29	73.46	76.66	71.08	69.18
3	62.30	76.69	62.73	47.72	75.96	78.92	73.26	70.39
4	61.42	75.90	61.85	47.16	78.06	81.02	75.19	71.32
5	60.73	75.26	61.02	46.63	79.69	82.79	77.05	72.26
6	60.16	74.67	60.38	46.10	80.97	84.35	78.71	73.34
7	59.63	74.20	59.80	45.64	81.96	85.83	80.31	74.28
8	59.98	74.88	59.47	45.48	81.35	84.75	81.49	74.95
9	62.08	77.16	61.11	47.33	77.17	79.47	78.44	72.02
10	65.10	79.89	64.63	50.38	70.71	72.76	70.26	65.97
11	68.14	82.44	68.31	53.46	63.13	66.80	61.55	60.06
12	70.81	84.69	71.49	56.17	57.01	61.69	54.38	55.04
13	72.85	86.56	74.05	58.35	52.54	57.72	48.96	50.92
14	74.55	87.97	76.02	60.04	49.43	54.55	45.19	47.85
15	75.77	89.08	77.43	61.16	47.28	51.89	42.81	45.99
16	76.55	89.74	78.32	61.67	46.06	50.27	41.13	45.03
17	76.91	89.91	78.56	61.33	45.70	49.54	40.60	45.85
18	76.64	89.53	77.75	59.42	45.79	49.98	41.44	49.13
19	75.61	88.58	75.47	56.23	47.37	51.47	45.13	54.42
20	73.43	86.79	72.43	54.18	50.98	54.78	51.13	58.23
21	70.64	84.28	70.09	52.82	56.49	60.06	55.99	60.70
22	68.60	82.18	68.45	51.69	60.76	65.23	59.81	62.94
23	67.04	80.77	67.05	50.71	64.37	68.65	62.89	65.01
24	65.66	79.58	65.76	49.84	67.56	71.49	65.97	66.52

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.7. Meteorological Inputs to MOVES for the Houston District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	68.64	79.90	69.43	58.42	81.35	83.91	81.67	82.45
2	68.12	79.38	68.98	58.09	82.54	85.42	83.00	83.01
3	67.68	78.93	68.40	57.86	83.35	86.55	83.99	83.49
4	67.26	78.53	67.90	57.63	83.95	87.52	84.97	83.84
5	66.87	78.16	67.44	57.45	84.72	88.47	85.90	84.32
6	66.60	77.87	67.03	57.20	85.01	88.87	86.56	84.62
7	66.42	77.72	66.73	57.08	85.29	89.25	87.17	84.93
8	67.01	78.85	66.76	57.43	83.88	86.51	87.11	84.58
9	69.10	81.23	68.64	59.26	79.04	80.14	82.80	81.15
10	71.45	83.31	71.70	61.47	72.52	73.84	74.82	75.13
11	73.61	85.10	74.54	63.66	65.80	68.00	66.59	69.24
12	75.38	86.51	76.65	65.60	61.11	63.50	60.39	64.09
13	76.72	87.40	78.20	67.05	57.86	61.13	56.44	60.68
14	77.53	87.91	79.28	67.96	55.98	59.98	53.93	58.60
15	77.94	88.19	79.99	68.27	55.44	59.43	52.18	57.56
16	78.13	88.15	80.27	68.03	55.07	59.68	51.64	58.02
17	77.93	87.97	79.94	67.17	55.52	60.39	52.50	60.18
18	77.24	87.58	78.81	65.34	56.78	61.61	55.49	65.06
19	75.89	86.57	76.48	63.21	59.84	64.18	62.20	70.47
20	73.84	84.93	74.12	61.84	65.47	68.59	68.98	74.11
21	71.92	83.10	72.66	60.82	71.24	73.89	73.32	76.82
22	70.75	81.94	71.63	60.02	75.09	77.39	76.38	79.03
23	69.96	81.11	70.85	59.42	77.66	80.04	78.49	80.25
24	69.28	80.46	70.11	58.91	79.75	82.08	80.12	81.30

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.8. Meteorological Inputs to MOVES for the San Antonio District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	66.62	78.88	66.45	53.47	79.02	76.02	78.14	77.41
2	65.76	77.68	65.72	52.89	81.17	79.77	80.85	78.76
3	64.96	76.73	65.08	52.39	83.33	82.75	82.52	80.01
4	64.35	75.96	64.64	51.95	84.73	85.07	83.89	80.70
5	63.83	75.38	64.25	51.56	85.87	86.72	84.30	81.48
6	63.35	74.89	63.88	51.25	86.72	88.11	84.58	81.81
7	63.09	74.48	63.51	50.94	87.04	89.07	84.94	82.30
8	63.38	75.02	63.26	50.95	86.80	88.42	85.28	82.29
9	65.15	77.43	64.63	53.01	83.46	82.71	82.85	78.84
10	67.61	80.29	67.86	56.30	77.51	73.71	75.95	71.62
11	70.03	83.10	71.12	59.54	70.97	65.04	67.66	64.76
12	72.48	85.71	74.02	62.53	65.05	57.98	60.46	57.97
13	74.82	88.05	76.47	64.98	59.77	51.94	54.76	52.79
14	76.86	89.96	78.57	66.87	55.39	47.53	50.17	49.24
15	78.42	91.51	80.08	68.14	52.09	44.11	46.79	46.99
16	79.49	92.58	81.03	68.70	49.89	42.08	44.93	45.76
17	79.99	93.08	81.31	68.31	48.88	40.73	44.43	46.65
18	79.80	92.95	80.72	66.37	48.90	41.16	45.34	50.57
19	78.66	91.90	78.39	62.93	50.89	43.00	50.00	56.52
20	76.17	89.86	74.84	60.02	55.89	47.30	56.90	62.21
21	73.02	86.67	72.12	57.98	62.34	54.51	62.79	66.52
22	70.65	83.99	70.29	56.40	67.84	61.17	67.48	70.50
23	68.97	81.98	68.81	55.25	72.35	66.75	71.45	73.16
24	67.65	80.30	67.56	54.20	75.96	71.71	74.98	75.39

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.9. Meteorological Inputs to MOVES for the Waco District

Hour ID	Temperature (degrees F.)				Relative Humidity (%)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	64.33	78.30	64.58	50.00	77.71	77.44	73.30	76.49
2	63.30	77.37	63.86	49.41	80.71	79.89	75.90	77.36
3	62.39	76.45	63.08	48.87	82.77	82.59	77.40	77.99
4	61.85	75.64	62.21	48.35	84.48	84.83	79.29	78.42
5	61.33	74.92	61.41	47.85	85.89	86.81	81.21	78.79
6	60.86	74.32	60.77	47.21	87.12	88.58	82.73	79.38
7	60.55	73.86	60.18	46.83	87.73	89.94	84.13	79.59
8	61.01	74.82	59.86	46.93	86.93	88.37	84.91	79.78
9	63.01	77.45	61.70	49.14	82.91	82.24	81.53	76.14
10	65.81	80.44	65.52	52.54	76.24	73.90	73.54	69.16
11	68.57	83.11	69.40	55.59	69.30	67.00	64.72	63.31
12	70.93	85.50	72.60	58.19	63.84	61.31	57.36	58.83
13	73.20	87.46	75.11	60.32	58.72	56.98	51.96	54.84
14	74.93	89.06	77.10	61.79	55.39	53.61	47.89	52.56
15	76.30	90.18	78.52	62.73	53.11	50.99	45.32	50.99
16	77.18	90.91	79.36	62.89	51.93	49.58	43.82	50.99
17	77.57	91.11	79.36	62.27	51.11	49.17	43.54	52.34
18	77.17	90.80	78.28	59.93	51.42	49.61	45.23	56.70
19	75.89	89.85	75.68	56.59	53.39	51.26	50.19	62.25
20	73.17	87.81	72.35	54.61	58.89	54.86	56.62	65.85
21	70.06	84.71	69.92	53.15	65.15	61.62	61.39	69.16
22	68.05	82.35	68.18	52.08	69.68	67.11	65.16	71.84
23	66.64	80.77	66.93	51.35	72.74	71.03	67.92	73.83
24	65.34	79.43	65.64	50.70	75.44	74.36	70.66	75.45

*2017 hourly averages of seasonal period data from district weather stations: March through May (Spring); June through August (Summer); September through November (Fall); December, January, February (Winter). Hour ID 1 is 12 a.m. to 1 a.m., etc. Shaded Hour IDs were used in project scale runs.

B.10. Annual Average Barometric Pressure by District

District	Barometric Pressure (inches of mercury)
Austin	29.05
Beaumont	29.96
Corpus Christi	29.88
Dallas	29.40
El Paso	26.17
Fort Worth	29.16
Houston	29.93
San Antonio	29.08
Waco	29.17

* Based on 2017 district weather station data.

APPENDIX C – MOVES SOURCE TYPE AGE DISTRIBUTIONS INPUTS

The age distributions are based on a combination of the latest available (2018 end-of-year) Texas Department of Motor Vehicles (TxDMV) county registration data, aggregated to the TxDOT district level or statewide level, and MOVES defaults selected based on the latest model year of the TxDMV data extract. The buses, refuse trucks, and motor home source types are MOVES defaults, long-haul trucks are based on state-level registration aggregations, and the remaining source types are based on TxDOT district level aggregations.

C.1. Source Type Labels and Descriptions

Source Type Label	Description
MC	Motorcycle
PC	Passenger Cars
PT	Passenger Truck
LCT	Light Commercial Truck
IBus	Intercity Bus
TBus	Transit Bus
SBus	School Bus
RT	Refuse Truck
SUShT	Single Unit Shot-HaulTruck
SULhT	Single Unit Long-Haul Truck
MH	Motor Home
CShT	Combination Short-Haul Truck
CLhT	Combination Long-Haul Truck

C.2. Austin 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.05605	0.06937	0.05731	0.05731	0.05774	0.05773	0.05776	0.06524	0.11098	0.10895	0.06536	0.06581	0.06883
1	0.06334	0.08490	0.06439	0.06439	0.05719	0.05714	0.05722	0.06513	0.09989	0.10365	0.06552	0.06222	0.05954
2	0.06090	0.08013	0.05555	0.05555	0.05503	0.05496	0.05506	0.06331	0.11067	0.11127	0.06402	0.06521	0.04790
3	0.06256	0.08260	0.05505	0.05505	0.05443	0.05438	0.05447	0.06248	0.09693	0.08575	0.06340	0.07494	0.06068
4	0.06123	0.08700	0.05503	0.05503	0.05235	0.05232	0.05240	0.05980	0.10839	0.10245	0.06087	0.07652	0.07197
5	0.05915	0.07457	0.05334	0.05334	0.04769	0.04775	0.04773	0.05441	0.05529	0.05603	0.05552	0.05770	0.05726
6	0.05169	0.07278	0.04648	0.04648	0.04218	0.04224	0.04222	0.04799	0.04705	0.05081	0.04899	0.05058	0.05812
7	0.04821	0.05967	0.03841	0.03841	0.03844	0.03850	0.03848	0.04332	0.06754	0.07144	0.04423	0.04345	0.06003
8	0.02946	0.04689	0.03841	0.03841	0.03469	0.04576	0.02683	0.02294	0.04822	0.04883	0.03220	0.02317	0.03087
9	0.02591	0.04149	0.03383	0.03383	0.03020	0.02762	0.02892	0.01783	0.01535	0.01704	0.02789	0.01729	0.02000
10	0.05905	0.03277	0.02740	0.02740	0.02495	0.02784	0.03395	0.02325	0.01470	0.01619	0.02298	0.02485	0.02743
11	0.04883	0.04382	0.04489	0.04489	0.03178	0.03853	0.03673	0.01764	0.03795	0.04138	0.02915	0.02649	0.02481
12	0.05885	0.04120	0.04733	0.04733	0.04110	0.03694	0.03756	0.06061	0.02701	0.02706	0.03745	0.07282	0.07872
13	0.05228	0.03302	0.04371	0.04371	0.04143	0.02614	0.04332	0.04432	0.03050	0.03020	0.03745	0.04715	0.05090
14	0.03945	0.02851	0.03801	0.03801	0.04227	0.04032	0.03809	0.04107	0.02724	0.02570	0.03805	0.03867	0.04309
15	0.03170	0.02400	0.04272	0.04272	0.04070	0.03276	0.03718	0.02430	0.01999	0.01923	0.03642	0.02393	0.02442
16	0.03564	0.02047	0.04058	0.04058	0.03709	0.03156	0.03148	0.02336	0.01682	0.01579	0.03303	0.02262	0.02162
17	0.02793	0.01644	0.03867	0.03867	0.03428	0.03157	0.03263	0.01665	0.01413	0.01349	0.03042	0.01419	0.01686
18	0.02126	0.01319	0.03689	0.03689	0.03234	0.03568	0.02921	0.02000	0.01405	0.01353	0.02847	0.02322	0.02354
19	0.01709	0.01104	0.02902	0.02902	0.03035	0.02382	0.03136	0.02685	0.00975	0.00983	0.02660	0.03432	0.03223
20	0.01292	0.00848	0.02235	0.02235	0.02901	0.02271	0.02854	0.03757	0.00957	0.00937	0.02519	0.02513	0.02437
21	0.00950	0.00573	0.01483	0.01483	0.02162	0.02620	0.02214	0.03381	0.00369	0.00451	0.01450	0.01985	0.01839
22	0.00833	0.00435	0.01541	0.01541	0.01739	0.02367	0.02039	0.01611	0.00415	0.00468	0.02200	0.01148	0.01267
23	0.00690	0.00265	0.01053	0.01053	0.01413	0.02143	0.01728	0.02044	0.00185	0.00232	0.01328	0.01354	0.01238
24	0.00566	0.00238	0.00980	0.00980	0.01812	0.01733	0.02178	0.02578	0.00206	0.00239	0.01541	0.01354	0.01177
25	0.00391	0.00171	0.00823	0.00823	0.01379	0.01493	0.01039	0.01786	0.00128	0.00141	0.01445	0.01006	0.00808
26	0.00355	0.00134	0.00554	0.00554	0.01119	0.01222	0.01224	0.00798	0.00087	0.00107	0.00976	0.00805	0.00627
27	0.00264	0.00105	0.00394	0.00394	0.00815	0.01049	0.00976	0.00700	0.00063	0.00071	0.00840	0.00446	0.00387
28	0.00189	0.00099	0.00302	0.00302	0.00913	0.01049	0.01232	0.01080	0.00056	0.00073	0.00617	0.00495	0.00364
29	0.00156	0.00078	0.00243	0.00243	0.01011	0.01514	0.01372	0.00752	0.00043	0.00065	0.00793	0.00451	0.00349
30	0.03255	0.00666	0.01689	0.01689	0.02115	0.02184	0.01884	0.01462	0.00247	0.00352	0.01492	0.01925	0.01626

C.3. Beaumont 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.06055	0.06151	0.05035	0.05035	0.05774	0.05773	0.05776	0.06524	0.09832	0.10895	0.06536	0.04550	0.06883
1	0.06477	0.08416	0.06845	0.06845	0.05719	0.05714	0.05722	0.06513	0.11332	0.10365	0.06552	0.05359	0.05954
2	0.05378	0.08634	0.06152	0.06152	0.05503	0.05496	0.05506	0.06331	0.12848	0.11127	0.06402	0.04517	0.04790
3	0.05685	0.07454	0.04749	0.04749	0.05443	0.05438	0.05447	0.06248	0.09752	0.08575	0.06340	0.04226	0.06068
4	0.04995	0.07987	0.05153	0.05153	0.05235	0.05232	0.05240	0.05980	0.10205	0.10245	0.06087	0.06088	0.07197
5	0.04867	0.06861	0.05627	0.05627	0.04769	0.04775	0.04773	0.05441	0.05776	0.05603	0.05552	0.04453	0.05726
6	0.04688	0.06227	0.04366	0.04366	0.04218	0.04224	0.04222	0.04799	0.05062	0.05081	0.04899	0.04971	0.05812
7	0.04152	0.05230	0.03825	0.03825	0.03844	0.03850	0.03848	0.04332	0.07048	0.07144	0.04423	0.05003	0.06003
8	0.02734	0.04310	0.03752	0.03752	0.03469	0.04576	0.02683	0.02294	0.04826	0.04883	0.03220	0.03287	0.03087
9	0.02823	0.03779	0.03143	0.03143	0.03020	0.02762	0.02892	0.01783	0.01416	0.01704	0.02789	0.01603	0.02000
10	0.05991	0.03261	0.02805	0.02805	0.02495	0.02784	0.03395	0.02325	0.01488	0.01619	0.02298	0.03125	0.02743
11	0.05493	0.04707	0.04919	0.04919	0.03178	0.03853	0.03673	0.01764	0.03614	0.04138	0.02915	0.02882	0.02481
12	0.05787	0.04605	0.04818	0.04818	0.04110	0.03694	0.03756	0.06061	0.02511	0.02706	0.03745	0.08614	0.07872
13	0.06145	0.03869	0.04647	0.04647	0.04143	0.02614	0.04332	0.04432	0.02780	0.03020	0.03745	0.04922	0.05090
14	0.04714	0.03329	0.03660	0.03660	0.04227	0.04032	0.03809	0.04107	0.02142	0.02570	0.03805	0.04663	0.04309
15	0.03705	0.02830	0.04105	0.04105	0.04070	0.03276	0.03718	0.02430	0.01605	0.01923	0.03642	0.03028	0.02442
16	0.04216	0.02484	0.04049	0.04049	0.03709	0.03156	0.03148	0.02336	0.01532	0.01579	0.03303	0.02558	0.02162
17	0.03539	0.02121	0.04042	0.04042	0.03428	0.03157	0.03263	0.01665	0.01296	0.01349	0.03042	0.02429	0.01686
18	0.02759	0.01667	0.03732	0.03732	0.03234	0.03568	0.02921	0.02000	0.01300	0.01353	0.02847	0.02672	0.02354
19	0.01942	0.01428	0.02800	0.02800	0.03035	0.02382	0.03136	0.02685	0.00810	0.00983	0.02660	0.03951	0.03223
20	0.01750	0.01152	0.02262	0.02262	0.02901	0.02271	0.02854	0.03757	0.00887	0.00937	0.02519	0.03141	0.02437
21	0.00984	0.00817	0.01599	0.01599	0.02162	0.02620	0.02214	0.03381	0.00365	0.00451	0.01450	0.02623	0.01839
22	0.01035	0.00611	0.01719	0.01719	0.01739	0.02367	0.02039	0.01611	0.00505	0.00468	0.02200	0.01813	0.01267
23	0.00703	0.00386	0.01251	0.01251	0.01413	0.02143	0.01728	0.02044	0.00209	0.00232	0.01328	0.01619	0.01238
24	0.00613	0.00353	0.01103	0.01103	0.01812	0.01733	0.02178	0.02578	0.00225	0.00239	0.01541	0.01652	0.01177
25	0.00562	0.00234	0.00933	0.00933	0.01379	0.01493	0.01039	0.01786	0.00136	0.00141	0.01445	0.01069	0.00808
26	0.00281	0.00173	0.00575	0.00575	0.01119	0.01222	0.01224	0.00798	0.00100	0.00107	0.00976	0.00955	0.00627
27	0.00128	0.00126	0.00429	0.00429	0.00815	0.01049	0.00976	0.00700	0.00060	0.00071	0.00840	0.00486	0.00387
28	0.00141	0.00117	0.00343	0.00343	0.00913	0.01049	0.01232	0.01080	0.00040	0.00073	0.00617	0.00518	0.00364
29	0.00128	0.00081	0.00280	0.00280	0.01011	0.01514	0.01372	0.00752	0.00064	0.00065	0.00793	0.00583	0.00349
30	0.01533	0.00602	0.01283	0.01283	0.02115	0.02184	0.01884	0.01462	0.00233	0.00352	0.01492	0.02639	0.01626

C.4. Corpus Christi 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.06001	0.06716	0.05519	0.05519	0.05774	0.05773	0.05776	0.06524	0.11868	0.10895	0.06536	0.04387	0.06883
1	0.06126	0.08844	0.06935	0.06935	0.05719	0.05714	0.05722	0.06513	0.10294	0.10365	0.06552	0.04849	0.05954
2	0.05170	0.08101	0.05706	0.05706	0.05503	0.05496	0.05506	0.06331	0.12857	0.11127	0.06402	0.02790	0.04790
3	0.06486	0.08011	0.05266	0.05266	0.05443	0.05438	0.05447	0.06248	0.07912	0.08575	0.06340	0.03939	0.06068
4	0.05932	0.08758	0.05702	0.05702	0.05235	0.05232	0.05240	0.05980	0.11834	0.10245	0.06087	0.07699	0.07197
5	0.05863	0.07583	0.06221	0.06221	0.04769	0.04775	0.04773	0.05441	0.06152	0.05603	0.05552	0.05237	0.05726
6	0.05891	0.06967	0.05254	0.05254	0.04218	0.04224	0.04222	0.04799	0.05778	0.05081	0.04899	0.08311	0.05812
7	0.05211	0.05679	0.04527	0.04527	0.03844	0.03850	0.03848	0.04332	0.09136	0.07144	0.04423	0.08550	0.06003
8	0.03368	0.04433	0.04087	0.04087	0.03469	0.04576	0.02683	0.02294	0.05253	0.04883	0.03220	0.02954	0.03087
9	0.03216	0.03842	0.03352	0.03352	0.03020	0.02762	0.02892	0.01783	0.01393	0.01704	0.02789	0.01641	0.02000
10	0.05489	0.02825	0.02452	0.02452	0.02495	0.02784	0.03395	0.02325	0.01262	0.01619	0.02298	0.03342	0.02743
11	0.05586	0.04353	0.04490	0.04490	0.03178	0.03853	0.03673	0.01764	0.03107	0.04138	0.02915	0.03074	0.02481
12	0.05225	0.04041	0.04485	0.04485	0.04110	0.03694	0.03756	0.06061	0.02069	0.02706	0.03745	0.08341	0.07872
13	0.04962	0.03360	0.04174	0.04174	0.04143	0.02614	0.04332	0.04432	0.02154	0.03020	0.03745	0.05312	0.05090
14	0.04269	0.03041	0.03654	0.03654	0.04227	0.04032	0.03809	0.04107	0.01756	0.02570	0.03805	0.05267	0.04309
15	0.03534	0.02571	0.04021	0.04021	0.04070	0.03276	0.03718	0.02430	0.01351	0.01923	0.03642	0.02596	0.02442
16	0.03617	0.02368	0.03885	0.03885	0.03709	0.03156	0.03148	0.02336	0.01112	0.01579	0.03303	0.02283	0.02162
17	0.02606	0.01925	0.03610	0.03610	0.03428	0.03157	0.03263	0.01665	0.00988	0.01349	0.03042	0.01716	0.01686
18	0.02384	0.01470	0.03498	0.03498	0.03234	0.03568	0.02921	0.02000	0.01042	0.01353	0.02847	0.02328	0.02354
19	0.01719	0.01219	0.02632	0.02632	0.03035	0.02382	0.03136	0.02685	0.00641	0.00983	0.02660	0.02626	0.03223
20	0.01608	0.00919	0.02053	0.02053	0.02901	0.02271	0.02854	0.03757	0.00521	0.00937	0.02519	0.02462	0.02437
21	0.00804	0.00616	0.01541	0.01541	0.02162	0.02620	0.02214	0.03381	0.00344	0.00451	0.01450	0.01701	0.01839
22	0.00541	0.00487	0.01505	0.01505	0.01739	0.02367	0.02039	0.01611	0.00289	0.00468	0.02200	0.01298	0.01267
23	0.00485	0.00333	0.01027	0.01027	0.01413	0.02143	0.01728	0.02044	0.00151	0.00232	0.01328	0.01119	0.01238
24	0.00596	0.00306	0.00969	0.00969	0.01812	0.01733	0.02178	0.02578	0.00143	0.00239	0.01541	0.01283	0.01177
25	0.00416	0.00190	0.00807	0.00807	0.01379	0.01493	0.01039	0.01786	0.00096	0.00141	0.01445	0.00955	0.00808
26	0.00277	0.00151	0.00527	0.00527	0.01119	0.01222	0.01224	0.00798	0.00127	0.00107	0.00976	0.01000	0.00627
27	0.00194	0.00097	0.00382	0.00382	0.00815	0.01049	0.00976	0.00700	0.00046	0.00071	0.00840	0.00418	0.00387
28	0.00055	0.00101	0.00299	0.00299	0.00913	0.01049	0.01232	0.01080	0.00046	0.00073	0.00617	0.00448	0.00364
29	0.00208	0.00081	0.00266	0.00266	0.01011	0.01514	0.01372	0.00752	0.00081	0.00065	0.00793	0.00313	0.00349
30	0.02162	0.00612	0.01159	0.01159	0.02115	0.02184	0.01884	0.01462	0.00197	0.00352	0.01492	0.01761	0.01626

C.5. Dallas 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.05982	0.06862	0.05989	0.05989	0.05774	0.05773	0.05776	0.06524	0.12405	0.10895	0.06536	0.09243	0.06883
1	0.06666	0.08094	0.06498	0.06498	0.05719	0.05714	0.05722	0.06513	0.10333	0.10365	0.06552	0.07648	0.05954
2	0.06044	0.07860	0.05368	0.05368	0.05503	0.05496	0.05506	0.06331	0.10361	0.11127	0.06402	0.06597	0.04790
3	0.06755	0.07950	0.05581	0.05581	0.05443	0.05438	0.05447	0.06248	0.08601	0.08575	0.06340	0.08005	0.06068
4	0.05955	0.08158	0.05044	0.05044	0.05235	0.05232	0.05240	0.05980	0.09380	0.10245	0.06087	0.07918	0.07197
5	0.06099	0.07182	0.05139	0.05139	0.04769	0.04775	0.04773	0.05441	0.05172	0.05603	0.05552	0.06177	0.05726
6	0.05244	0.06901	0.04402	0.04402	0.04218	0.04224	0.04222	0.04799	0.04938	0.05081	0.04899	0.05714	0.05812
7	0.04776	0.05810	0.03693	0.03693	0.03844	0.03850	0.03848	0.04332	0.06432	0.07144	0.04423	0.04923	0.06003
8	0.02982	0.04663	0.03727	0.03727	0.03469	0.04576	0.02683	0.02294	0.04408	0.04883	0.03220	0.02658	0.03087
9	0.02523	0.04140	0.03390	0.03390	0.03020	0.02762	0.02892	0.01783	0.01926	0.01704	0.02789	0.01988	0.02000
10	0.05293	0.03363	0.02559	0.02559	0.02495	0.02784	0.03395	0.02325	0.01723	0.01619	0.02298	0.02714	0.02743
11	0.04895	0.04621	0.04739	0.04739	0.03178	0.03853	0.03673	0.01764	0.04714	0.04138	0.02915	0.02194	0.02481
12	0.06194	0.04516	0.05003	0.05003	0.04110	0.03694	0.03756	0.06061	0.02885	0.02706	0.03745	0.07231	0.07872
13	0.05420	0.03564	0.04361	0.04361	0.04143	0.02614	0.04332	0.04432	0.03365	0.03020	0.03745	0.04811	0.05090
14	0.04309	0.03130	0.04030	0.04030	0.04227	0.04032	0.03809	0.04107	0.02643	0.02570	0.03805	0.03498	0.04309
15	0.03176	0.02678	0.04454	0.04454	0.04070	0.03276	0.03718	0.02430	0.01801	0.01923	0.03642	0.01883	0.02442
16	0.03786	0.02310	0.04043	0.04043	0.03709	0.03156	0.03148	0.02336	0.01482	0.01579	0.03303	0.01670	0.02162
17	0.02933	0.01880	0.03991	0.03991	0.03428	0.03157	0.03263	0.01665	0.01532	0.01349	0.03042	0.01673	0.01686
18	0.02210	0.01497	0.03672	0.03672	0.03234	0.03568	0.02921	0.02000	0.01448	0.01353	0.02847	0.02087	0.02354
19	0.01661	0.01255	0.02901	0.02901	0.03035	0.02382	0.03136	0.02685	0.01221	0.00983	0.02660	0.02786	0.03223
20	0.01224	0.00924	0.02315	0.02315	0.02901	0.02271	0.02854	0.03757	0.01069	0.00937	0.02519	0.02041	0.02437
21	0.00931	0.00622	0.01612	0.01612	0.02162	0.02620	0.02214	0.03381	0.00508	0.00451	0.01450	0.01439	0.01839
22	0.00695	0.00456	0.01576	0.01576	0.01739	0.02367	0.02039	0.01611	0.00508	0.00468	0.02200	0.01070	0.01267
23	0.00572	0.00292	0.01047	0.01047	0.01413	0.02143	0.01728	0.02044	0.00254	0.00232	0.01328	0.00879	0.01238
24	0.00475	0.00236	0.00965	0.00965	0.01812	0.01733	0.02178	0.02578	0.00271	0.00239	0.01541	0.00833	0.01177
25	0.00337	0.00158	0.00809	0.00809	0.01379	0.01493	0.01039	0.01786	0.00142	0.00141	0.01445	0.00476	0.00808
26	0.00309	0.00115	0.00511	0.00511	0.01119	0.01222	0.01224	0.00798	0.00092	0.00107	0.00976	0.00413	0.00627
27	0.00176	0.00089	0.00354	0.00354	0.00815	0.01049	0.00976	0.00700	0.00054	0.00071	0.00840	0.00277	0.00387
28	0.00170	0.00081	0.00272	0.00272	0.00913	0.01049	0.01232	0.01080	0.00059	0.00073	0.00617	0.00219	0.00364
29	0.00135	0.00065	0.00260	0.00260	0.01011	0.01514	0.01372	0.00752	0.00058	0.00065	0.00793	0.00206	0.00349
30	0.02075	0.00527	0.01693	0.01693	0.02115	0.02184	0.01884	0.01462	0.00216	0.00352	0.01492	0.00726	0.01626

C.6. El Paso 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.04533	0.05390	0.04836	0.04836	0.05774	0.05773	0.05776	0.06524	0.07330	0.10895	0.06536	0.07188	0.06883
1	0.05053	0.06589	0.04800	0.04800	0.05719	0.05714	0.05722	0.06513	0.08464	0.10365	0.06552	0.05580	0.05954
2	0.04570	0.06926	0.04924	0.04924	0.05503	0.05496	0.05506	0.06331	0.08344	0.11127	0.06402	0.04126	0.04790
3	0.06418	0.07095	0.04681	0.04681	0.05443	0.05438	0.05447	0.06248	0.07450	0.08575	0.06340	0.07205	0.06068
4	0.06158	0.07675	0.04427	0.04427	0.05235	0.05232	0.05240	0.05980	0.08289	0.10245	0.06087	0.07009	0.07197
5	0.06121	0.06671	0.04688	0.04688	0.04769	0.04775	0.04773	0.05441	0.05191	0.05603	0.05552	0.05801	0.05726
6	0.05666	0.06150	0.03346	0.03346	0.04218	0.04224	0.04222	0.04799	0.03660	0.05081	0.04899	0.06056	0.05812
7	0.04709	0.05107	0.03068	0.03068	0.03844	0.03850	0.03848	0.04332	0.06122	0.07144	0.04423	0.06516	0.06003
8	0.03000	0.03943	0.03106	0.03106	0.03469	0.04576	0.02683	0.02294	0.04638	0.04883	0.03220	0.03437	0.03087
9	0.02861	0.03980	0.03014	0.03014	0.03020	0.02762	0.02892	0.01783	0.02563	0.01704	0.02789	0.02594	0.02000
10	0.05712	0.03234	0.02484	0.02484	0.02495	0.02784	0.03395	0.02325	0.02277	0.01619	0.02298	0.03581	0.02743
11	0.05490	0.04895	0.04717	0.04717	0.03178	0.03853	0.03673	0.01764	0.06472	0.04138	0.02915	0.02390	0.02481
12	0.06706	0.04962	0.04919	0.04919	0.04110	0.03694	0.03756	0.06061	0.03052	0.02706	0.03745	0.06278	0.07872
13	0.05304	0.04319	0.04549	0.04549	0.04143	0.02614	0.04332	0.04432	0.04711	0.03020	0.03745	0.04585	0.05090
14	0.04570	0.03967	0.04452	0.04452	0.04227	0.04032	0.03809	0.04107	0.03448	0.02570	0.03805	0.04015	0.04309
15	0.03307	0.03366	0.04813	0.04813	0.04070	0.03276	0.03718	0.02430	0.02867	0.01923	0.03642	0.01948	0.02442
16	0.04375	0.03033	0.04174	0.04174	0.03709	0.03156	0.03148	0.02336	0.02535	0.01579	0.03303	0.02263	0.02162
17	0.02972	0.02532	0.04128	0.04128	0.03428	0.03157	0.03263	0.01665	0.01881	0.01349	0.03042	0.01599	0.01686
18	0.02434	0.01957	0.03894	0.03894	0.03234	0.03568	0.02921	0.02000	0.01724	0.01353	0.02847	0.02297	0.02354
19	0.01495	0.01780	0.03289	0.03289	0.03035	0.02382	0.03136	0.02685	0.01936	0.00983	0.02660	0.03692	0.03223
20	0.01681	0.01299	0.02588	0.02588	0.02901	0.02271	0.02854	0.03757	0.01567	0.00937	0.02519	0.02926	0.02437
21	0.01077	0.01000	0.02084	0.02084	0.02162	0.02620	0.02214	0.03381	0.00655	0.00451	0.01450	0.01761	0.01839
22	0.00734	0.00758	0.02112	0.02112	0.01739	0.02367	0.02039	0.01611	0.01199	0.00468	0.02200	0.01335	0.01267
23	0.00687	0.00513	0.01386	0.01386	0.01413	0.02143	0.01728	0.02044	0.00526	0.00232	0.01328	0.01004	0.01238
24	0.00464	0.00488	0.01438	0.01438	0.01812	0.01733	0.02178	0.02578	0.00636	0.00239	0.01541	0.00944	0.01177
25	0.00427	0.00355	0.01350	0.01350	0.01379	0.01493	0.01039	0.01786	0.00396	0.00141	0.01445	0.00715	0.00808
26	0.00288	0.00271	0.00896	0.00896	0.01119	0.01222	0.01224	0.00798	0.00267	0.00107	0.00976	0.00587	0.00627
27	0.00214	0.00215	0.00732	0.00732	0.00815	0.01049	0.00976	0.00700	0.00258	0.00071	0.00840	0.00468	0.00387
28	0.00158	0.00186	0.00521	0.00521	0.00913	0.01049	0.01232	0.01080	0.00212	0.00073	0.00617	0.00349	0.00364
29	0.00242	0.00153	0.00470	0.00470	0.01011	0.01514	0.01372	0.00752	0.00212	0.00065	0.00793	0.00349	0.00349
30	0.02573	0.01192	0.04113	0.04113	0.02115	0.02184	0.01884	0.01462	0.01116	0.00352	0.01492	0.01404	0.01626

C.7. Fort Worth 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.05644	0.06335	0.05078	0.05078	0.05774	0.05773	0.05776	0.06524	0.10535	0.10895	0.06536	0.09338	0.06883
1	0.06213	0.07751	0.06263	0.06263	0.05719	0.05714	0.05722	0.06513	0.09936	0.10365	0.06552	0.07636	0.05954
2	0.05738	0.07578	0.05433	0.05433	0.05503	0.05496	0.05506	0.06331	0.11444	0.11127	0.06402	0.06006	0.04790
3	0.06283	0.07704	0.05006	0.05006	0.05443	0.05438	0.05447	0.06248	0.09330	0.08575	0.06340	0.08306	0.06068
4	0.06024	0.08043	0.05042	0.05042	0.05235	0.05232	0.05240	0.05980	0.10057	0.10245	0.06087	0.08329	0.07197
5	0.05822	0.07101	0.05414	0.05414	0.04769	0.04775	0.04773	0.05441	0.05321	0.05603	0.05552	0.06778	0.05726
6	0.04873	0.06802	0.04379	0.04379	0.04218	0.04224	0.04222	0.04799	0.05077	0.05081	0.04899	0.05803	0.05812
7	0.04449	0.05880	0.03706	0.03706	0.03844	0.03850	0.03848	0.04332	0.06946	0.07144	0.04423	0.05699	0.06003
8	0.03090	0.04775	0.03747	0.03747	0.03469	0.04576	0.02683	0.02294	0.04955	0.04883	0.03220	0.02958	0.03087
9	0.02721	0.04144	0.03341	0.03341	0.03020	0.02762	0.02892	0.01783	0.01743	0.01704	0.02789	0.01959	0.02000
10	0.05126	0.03421	0.02677	0.02677	0.02495	0.02784	0.03395	0.02325	0.01577	0.01619	0.02298	0.02486	0.02743
11	0.05355	0.04715	0.04708	0.04708	0.03178	0.03853	0.03673	0.01764	0.04163	0.04138	0.02915	0.02518	0.02481
12	0.06534	0.04606	0.04869	0.04869	0.04110	0.03694	0.03756	0.06061	0.02789	0.02706	0.03745	0.06736	0.07872
13	0.05415	0.03658	0.04334	0.04334	0.04143	0.02614	0.04332	0.04432	0.03180	0.03020	0.03745	0.04277	0.05090
14	0.04649	0.03273	0.04093	0.04093	0.04227	0.04032	0.03809	0.04107	0.02840	0.02570	0.03805	0.03339	0.04309
15	0.03368	0.02803	0.04535	0.04535	0.04070	0.03276	0.03718	0.02430	0.02060	0.01923	0.03642	0.01999	0.02442
16	0.03994	0.02429	0.04174	0.04174	0.03709	0.03156	0.03148	0.02336	0.01604	0.01579	0.03303	0.01952	0.02162
17	0.03123	0.02039	0.03991	0.03991	0.03428	0.03157	0.03263	0.01665	0.01324	0.01349	0.03042	0.01296	0.01686
18	0.02346	0.01598	0.03845	0.03845	0.03234	0.03568	0.02921	0.02000	0.01362	0.01353	0.02847	0.01969	0.02354
19	0.01718	0.01327	0.02963	0.02963	0.03035	0.02382	0.03136	0.02685	0.00914	0.00983	0.02660	0.02464	0.03223
20	0.01305	0.01000	0.02413	0.02413	0.02901	0.02271	0.02854	0.03757	0.00945	0.00937	0.02519	0.01788	0.02437
21	0.00911	0.00671	0.01686	0.01686	0.02162	0.02620	0.02214	0.03381	0.00441	0.00451	0.01450	0.01333	0.01839
22	0.00760	0.00506	0.01700	0.01700	0.01739	0.02367	0.02039	0.01611	0.00418	0.00468	0.02200	0.00890	0.01267
23	0.00704	0.00329	0.01147	0.01147	0.01413	0.02143	0.01728	0.02044	0.00185	0.00232	0.01328	0.00772	0.01238
24	0.00564	0.00267	0.01047	0.01047	0.01812	0.01733	0.02178	0.02578	0.00219	0.00239	0.01541	0.00784	0.01177
25	0.00388	0.00191	0.00891	0.00891	0.01379	0.01493	0.01039	0.01786	0.00121	0.00141	0.01445	0.00529	0.00808
26	0.00283	0.00143	0.00576	0.00576	0.01119	0.01222	0.01224	0.00798	0.00091	0.00107	0.00976	0.00411	0.00627
27	0.00197	0.00111	0.00422	0.00422	0.00815	0.01049	0.00976	0.00700	0.00047	0.00071	0.00840	0.00205	0.00387
28	0.00146	0.00100	0.00325	0.00325	0.00913	0.01049	0.01232	0.01080	0.00060	0.00073	0.00617	0.00213	0.00364
29	0.00167	0.00079	0.00301	0.00301	0.01011	0.01514	0.01372	0.00752	0.00057	0.00065	0.00793	0.00252	0.00349
30	0.02092	0.00621	0.01892	0.01892	0.02115	0.02184	0.01884	0.01462	0.00260	0.00352	0.01492	0.00975	0.01626

C.8. Houston 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.06351	0.06543	0.05443	0.05443	0.05774	0.05773	0.05776	0.06524	0.10674	0.10895	0.06536	0.05499	0.06883
1	0.07094	0.08231	0.06711	0.06711	0.05719	0.05714	0.05722	0.06513	0.09798	0.10365	0.06552	0.05652	0.05954
2	0.06125	0.07953	0.05368	0.05368	0.05503	0.05496	0.05506	0.06331	0.11267	0.11127	0.06402	0.04453	0.04790
3	0.06337	0.07774	0.05126	0.05126	0.05443	0.05438	0.05447	0.06248	0.08970	0.08575	0.06340	0.05417	0.06068
4	0.05986	0.08542	0.05387	0.05387	0.05235	0.05232	0.05240	0.05980	0.10148	0.10245	0.06087	0.06466	0.07197
5	0.05817	0.07388	0.05699	0.05699	0.04769	0.04775	0.04773	0.05441	0.05641	0.05603	0.05552	0.05645	0.05726
6	0.05315	0.06921	0.04823	0.04823	0.04218	0.04224	0.04222	0.04799	0.05366	0.05081	0.04899	0.05775	0.05812
7	0.04643	0.05744	0.04086	0.04086	0.03844	0.03850	0.03848	0.04332	0.06909	0.07144	0.04423	0.06387	0.06003
8	0.03077	0.04703	0.04104	0.04104	0.03469	0.04576	0.02683	0.02294	0.04813	0.04883	0.03220	0.03244	0.03087
9	0.02603	0.04080	0.03496	0.03496	0.03020	0.02762	0.02892	0.01783	0.01799	0.01704	0.02789	0.02215	0.02000
10	0.05371	0.03409	0.02875	0.02875	0.02495	0.02784	0.03395	0.02325	0.01814	0.01619	0.02298	0.02849	0.02743
11	0.05074	0.04638	0.05087	0.05087	0.03178	0.03853	0.03673	0.01764	0.04467	0.04138	0.02915	0.02633	0.02481
12	0.06195	0.04475	0.05235	0.05235	0.04110	0.03694	0.03756	0.06061	0.02857	0.02706	0.03745	0.08782	0.07872
13	0.05440	0.03590	0.04582	0.04582	0.04143	0.02614	0.04332	0.04432	0.03057	0.03020	0.03745	0.05690	0.05090
14	0.04305	0.03095	0.03981	0.03981	0.04227	0.04032	0.03809	0.04107	0.02424	0.02570	0.03805	0.04842	0.04309
15	0.03125	0.02584	0.04168	0.04168	0.04070	0.03276	0.03718	0.02430	0.01853	0.01923	0.03642	0.02898	0.02442
16	0.03718	0.02241	0.03917	0.03917	0.03709	0.03156	0.03148	0.02336	0.01474	0.01579	0.03303	0.02254	0.02162
17	0.03020	0.01870	0.03891	0.03891	0.03428	0.03157	0.03263	0.01665	0.01331	0.01349	0.03042	0.01856	0.01686
18	0.02043	0.01472	0.03548	0.03548	0.03234	0.03568	0.02921	0.02000	0.01319	0.01353	0.02847	0.02550	0.02354
19	0.01546	0.01226	0.02732	0.02732	0.03035	0.02382	0.03136	0.02685	0.01094	0.00983	0.02660	0.03521	0.03223
20	0.01217	0.00908	0.02072	0.02072	0.02901	0.02271	0.02854	0.03757	0.00954	0.00937	0.02519	0.02687	0.02437
21	0.00877	0.00629	0.01426	0.01426	0.02162	0.02620	0.02214	0.03381	0.00386	0.00451	0.01450	0.01986	0.01839
22	0.00649	0.00461	0.01382	0.01382	0.01739	0.02367	0.02039	0.01611	0.00448	0.00468	0.02200	0.01314	0.01267
23	0.00617	0.00280	0.00923	0.00923	0.01413	0.02143	0.01728	0.02044	0.00233	0.00232	0.01328	0.01198	0.01238
24	0.00457	0.00217	0.00813	0.00813	0.01812	0.01733	0.02178	0.02578	0.00218	0.00239	0.01541	0.01206	0.01177
25	0.00377	0.00153	0.00683	0.00683	0.01379	0.01493	0.01039	0.01786	0.00126	0.00141	0.01445	0.00744	0.00808
26	0.00277	0.00116	0.00438	0.00438	0.01119	0.01222	0.01224	0.00798	0.00098	0.00107	0.00976	0.00577	0.00627
27	0.00194	0.00089	0.00332	0.00332	0.00815	0.01049	0.00976	0.00700	0.00075	0.00071	0.00840	0.00369	0.00387
28	0.00123	0.00081	0.00249	0.00249	0.00913	0.01049	0.01232	0.01080	0.00071	0.00073	0.00617	0.00285	0.00364
29	0.00151	0.00064	0.00219	0.00219	0.01011	0.01514	0.01372	0.00752	0.00054	0.00065	0.00793	0.00229	0.00349
30	0.01877	0.00525	0.01202	0.01202	0.02115	0.02184	0.01884	0.01462	0.00260	0.00352	0.01492	0.00779	0.01626

C.9. San Antonio 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.05698	0.08050	0.06548	0.06548	0.05774	0.05773	0.05776	0.06524	0.10774	0.10895	0.06536	0.07837	0.06883
1	0.05795	0.08512	0.06230	0.06230	0.05719	0.05714	0.05722	0.06513	0.10385	0.10365	0.06552	0.06171	0.05954
2	0.05801	0.07612	0.05106	0.05106	0.05503	0.05496	0.05506	0.06331	0.10838	0.11127	0.06402	0.05660	0.04790
3	0.06356	0.07822	0.04975	0.04975	0.05443	0.05438	0.05447	0.06248	0.08480	0.08575	0.06340	0.05982	0.06068
4	0.05949	0.08206	0.04813	0.04813	0.05235	0.05232	0.05240	0.05980	0.10229	0.10245	0.06087	0.08347	0.07197
5	0.05786	0.06965	0.05115	0.05115	0.04769	0.04775	0.04773	0.05441	0.05972	0.05603	0.05552	0.05964	0.05726
6	0.05452	0.06562	0.04323	0.04323	0.04218	0.04224	0.04222	0.04799	0.04881	0.05081	0.04899	0.05160	0.05812
7	0.04803	0.05539	0.03764	0.03764	0.03844	0.03850	0.03848	0.04332	0.07318	0.07144	0.04423	0.05287	0.06003
8	0.03668	0.04407	0.03693	0.03693	0.03469	0.04576	0.02683	0.02294	0.04859	0.04883	0.03220	0.02560	0.03087
9	0.02761	0.03936	0.03375	0.03375	0.03020	0.02762	0.02892	0.01783	0.01623	0.01704	0.02789	0.01640	0.02000
10	0.05616	0.03133	0.02448	0.02448	0.02495	0.02784	0.03395	0.02325	0.01582	0.01619	0.02298	0.02622	0.02743
11	0.05594	0.04346	0.04334	0.04334	0.03178	0.03853	0.03673	0.01764	0.04014	0.04138	0.02915	0.02491	0.02481
12	0.06523	0.04184	0.04570	0.04570	0.04110	0.03694	0.03756	0.06061	0.02654	0.02706	0.03745	0.07286	0.07872
13	0.05628	0.03485	0.04331	0.04331	0.04143	0.02614	0.04332	0.04432	0.03034	0.03020	0.03745	0.04997	0.05090
14	0.04247	0.03183	0.03914	0.03914	0.04227	0.04032	0.03809	0.04107	0.02780	0.02570	0.03805	0.04610	0.04309
15	0.03158	0.02713	0.04423	0.04423	0.04070	0.03276	0.03718	0.02430	0.02134	0.01923	0.03642	0.02376	0.02442
16	0.03817	0.02356	0.04284	0.04284	0.03709	0.03156	0.03148	0.02336	0.01583	0.01579	0.03303	0.02202	0.02162
17	0.02703	0.01970	0.04125	0.04125	0.03428	0.03157	0.03263	0.01665	0.01516	0.01349	0.03042	0.01735	0.01686
18	0.01869	0.01574	0.03869	0.03869	0.03234	0.03568	0.02921	0.02000	0.01295	0.01353	0.02847	0.02075	0.02354
19	0.01529	0.01289	0.02925	0.02925	0.03035	0.02382	0.03136	0.02685	0.00922	0.00983	0.02660	0.03020	0.03223
20	0.01399	0.00985	0.02387	0.02387	0.02901	0.02271	0.02854	0.03757	0.00899	0.00937	0.02519	0.02238	0.02437
21	0.00795	0.00654	0.01664	0.01664	0.02162	0.02620	0.02214	0.03381	0.00461	0.00451	0.01450	0.01774	0.01839
22	0.00670	0.00507	0.01730	0.01730	0.01739	0.02367	0.02039	0.01611	0.00450	0.00468	0.02200	0.01220	0.01267
23	0.00628	0.00336	0.01172	0.01172	0.01413	0.02143	0.01728	0.02044	0.00200	0.00232	0.01328	0.01267	0.01238
24	0.00470	0.00306	0.01124	0.01124	0.01812	0.01733	0.02178	0.02578	0.00220	0.00239	0.01541	0.01177	0.01177
25	0.00385	0.00208	0.00975	0.00975	0.01379	0.01493	0.01039	0.01786	0.00130	0.00141	0.01445	0.00833	0.00808
26	0.00319	0.00157	0.00658	0.00658	0.01119	0.01222	0.01224	0.00798	0.00120	0.00107	0.00976	0.00554	0.00627
27	0.00279	0.00120	0.00487	0.00487	0.00815	0.01049	0.00976	0.00700	0.00076	0.00071	0.00840	0.00398	0.00387
28	0.00155	0.00106	0.00357	0.00357	0.00913	0.01049	0.01232	0.01080	0.00097	0.00073	0.00617	0.00373	0.00364
29	0.00167	0.00081	0.00294	0.00294	0.01011	0.01514	0.01372	0.00752	0.00068	0.00065	0.00793	0.00409	0.00349
30	0.01981	0.00698	0.01987	0.01987	0.02115	0.02184	0.01884	0.01462	0.00405	0.00352	0.01492	0.01731	0.01626

C.10. Waco 2018 Age Distribution Input to MOVES (used for all MOVES runs 2020-2050)

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.04989	0.05667	0.04802	0.04802	0.05774	0.05773	0.05776	0.06524	0.07930	0.10895	0.06536	0.06264	0.06264
1	0.05477	0.07619	0.05906	0.05906	0.05719	0.05714	0.05722	0.06513	0.09595	0.10365	0.06552	0.04116	0.04116
2	0.05062	0.07625	0.05062	0.05062	0.05503	0.05496	0.05506	0.06331	0.09402	0.11127	0.06402	0.04656	0.04656
3	0.06577	0.07668	0.04877	0.04877	0.05443	0.05438	0.05447	0.06248	0.08581	0.08575	0.06340	0.05529	0.05529
4	0.05681	0.07897	0.04822	0.04822	0.05235	0.05232	0.05240	0.05980	0.10066	0.10245	0.06087	0.06763	0.06763
5	0.05419	0.07112	0.04757	0.04757	0.04769	0.04775	0.04773	0.05441	0.05345	0.05603	0.05552	0.03963	0.03963
6	0.04894	0.06610	0.04007	0.04007	0.04218	0.04224	0.04222	0.04799	0.05058	0.05081	0.04899	0.04033	0.04033
7	0.04894	0.05681	0.03710	0.03710	0.03844	0.03850	0.03848	0.04332	0.07436	0.07144	0.04423	0.04060	0.04060
8	0.03234	0.04552	0.03567	0.03567	0.03469	0.04576	0.02683	0.02294	0.05175	0.04883	0.03220	0.02439	0.02439
9	0.02979	0.03920	0.03205	0.03205	0.03020	0.02762	0.02892	0.01783	0.01867	0.01704	0.02789	0.02037	0.02037
10	0.05819	0.03279	0.02615	0.02615	0.02495	0.02784	0.03395	0.02325	0.01714	0.01619	0.02298	0.02176	0.02176
11	0.05790	0.04504	0.04421	0.04421	0.03178	0.03853	0.03673	0.01764	0.04084	0.04138	0.02915	0.02051	0.02051
12	0.06737	0.04474	0.04759	0.04759	0.04110	0.03694	0.03756	0.06061	0.03415	0.02706	0.03745	0.07123	0.07123
13	0.06001	0.03766	0.04317	0.04317	0.04143	0.02614	0.04332	0.04432	0.03833	0.03020	0.03745	0.04892	0.04892
14	0.04741	0.03493	0.04120	0.04120	0.04227	0.04032	0.03809	0.04107	0.03442	0.02570	0.03805	0.04268	0.04268
15	0.03518	0.03060	0.04612	0.04612	0.04070	0.03276	0.03718	0.02430	0.02361	0.01923	0.03642	0.02633	0.02633
16	0.03838	0.02635	0.04250	0.04250	0.03709	0.03156	0.03148	0.02336	0.02109	0.01579	0.03303	0.02425	0.02425
17	0.03095	0.02205	0.04077	0.04077	0.03428	0.03157	0.03263	0.01665	0.01463	0.01349	0.03042	0.01760	0.01760
18	0.02265	0.01780	0.04107	0.04107	0.03234	0.03568	0.02921	0.02000	0.01701	0.01353	0.02847	0.03340	0.03340
19	0.01559	0.01507	0.03100	0.03100	0.03035	0.02382	0.03136	0.02685	0.01270	0.00983	0.02660	0.04351	0.04351
20	0.01580	0.01130	0.02579	0.02579	0.02901	0.02271	0.02854	0.03757	0.01135	0.00937	0.02519	0.03035	0.03035
21	0.00983	0.00787	0.01922	0.01922	0.02162	0.02620	0.02214	0.03381	0.00678	0.00451	0.01450	0.02730	0.02730
22	0.00619	0.00639	0.01958	0.01958	0.01739	0.02367	0.02039	0.01611	0.00601	0.00468	0.02200	0.01871	0.01871
23	0.00626	0.00430	0.01447	0.01447	0.01413	0.02143	0.01728	0.02044	0.00305	0.00232	0.01328	0.01926	0.01926
24	0.00510	0.00370	0.01326	0.01326	0.01812	0.01733	0.02178	0.02578	0.00319	0.00239	0.01541	0.02190	0.02190
25	0.00371	0.00246	0.01124	0.01124	0.01379	0.01493	0.01039	0.01786	0.00162	0.00141	0.01445	0.01746	0.01746
26	0.00328	0.00195	0.00756	0.00756	0.01119	0.01222	0.01224	0.00798	0.00135	0.00107	0.00976	0.01233	0.01233
27	0.00131	0.00148	0.00570	0.00570	0.00815	0.01049	0.00976	0.00700	0.00072	0.00071	0.00840	0.00762	0.00762
28	0.00124	0.00123	0.00434	0.00434	0.00913	0.01049	0.01232	0.01080	0.00103	0.00073	0.00617	0.00748	0.00748

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
29	0.00153	0.00097	0.00412	0.00412	0.01011	0.01514	0.01372	0.00752	0.00076	0.00065	0.00793	0.00790	0.00790
30	0.02003	0.007806	0.02380	0.02380	0.02115	0.02184	0.01884	0.01462	0.00565	0.00352	0.01492	0.04088	0.04088

APPENDIX D – MOVES AVFT (FUEL ENGINE FRACTIONS) INPUTS

D.1. Source Type Labels and Descriptions

Source Type Label	Description
MC	Motorcycle
PC	Passenger Cars
PT	Passenger Truck
LCT	Light Commercial Truck
IBus	Intercity Bus
TBus	Transit Bus
SBus	School Bus
RT	Refuse Truck
SUShT	Single Unit Shot-HaulTruck
SULhT	Single Unit Long-Haul Truck
MH	Motor Home
CShT	Combination Short-Haul Truck
CLhT	Combination Long-Haul Truck

D.2. Texas Statewide MOVES Fuel Engine Fractions Inputs Summary (model years 2050 back through 1990)

SUT	Fuel Type	Model Year															
		2050	2049	2048	2047	2046	2045	2044	2043	2042	2041	2040	2039	2038	2037	2036	2035
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988
PC	Diesel	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
PT	Gas	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980
PT	Diesel	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
LCT	Gas	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
LCT	Diesel	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
RT	Diesel	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
SUShT	Gas	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519
SUShT	Diesel	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481
SULhT	Gas	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519
SULhT	Diesel	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
CShT	Gas	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
CShT	Diesel	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Texas Statewide MOVES Fuel Engine Fractions Inputs Summary (model years 2050 back through 1990)-Continued

SUT	Fuel Type	Model Year														
		2034	2033	2032	2031	2030	2029	2028	2027	2026	2025	2024	2023	2022	2021	2020
MC	**Gas**	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	**Gas**	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988
PC	**Diesel**	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
PT	**Gas**	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980
PT	**Diesel**	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
LCT	**Gas**	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
LCT	**Diesel**	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
IBus	**Diesel**	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	**Gas**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	**Diesel**	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	**Gas**	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	**Diesel**	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	**Gas**	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
RT	**Diesel**	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
SUShT	**Gas**	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519
SUShT	**Diesel**	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481
SULhT	**Gas**	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519
SULhT	**Diesel**	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481
MH	**Gas**	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
MH	**Diesel**	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
CShT	**Gas**	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
CShT	**Diesel**	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919	0.919
CLhT	**Diesel**	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Texas Statewide MOVES Fuel Engine Fractions Inputs Summary (model years 2050 back through 1990)-Continued

SUT	Fuel Type	Model Year														
		2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.990	0.993	0.999	1.000	0.993	0.995
PC	Diesel	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.010	0.007	0.001	0.000	0.007	0.005
PT	Gas	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.987	0.985	0.977	0.981	0.975	0.979
PT	Diesel	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.013	0.015	0.023	0.019	0.025	0.021
LCT	Gas	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.962	0.955	0.941	0.948	0.938	0.946
LCT	Diesel	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.038	0.045	0.059	0.052	0.062	0.054
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990
RT	Gas	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.005	0.001	0.003	0.003
RT	Diesel	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.998	0.998	0.995	0.999	0.997	0.997
SUShT	Gas	0.519	0.474	0.499	0.490	0.443	0.400	0.421	0.275	0.284	0.332	0.383	0.331	0.272	0.273	0.249
SUShT	Diesel	0.481	0.526	0.501	0.510	0.557	0.600	0.579	0.725	0.716	0.668	0.617	0.669	0.728	0.727	0.751
SULhT	Gas	0.519	0.474	0.499	0.490	0.443	0.400	0.421	0.275	0.284	0.332	0.383	0.331	0.272	0.273	0.249
SULhT	Diesel	0.481	0.526	0.501	0.510	0.557	0.600	0.579	0.725	0.716	0.668	0.617	0.669	0.728	0.727	0.751
MH	Gas	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.510	0.530	0.540	0.560
MH	Diesel	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.490	0.470	0.460	0.440
CShT	Gas	0.081	0.091	0.106	0.093	0.073	0.098	0.087	0.081	0.065	0.077	0.077	0.079	0.054	0.065	0.061
CShT	Diesel	0.919	0.909	0.894	0.907	0.927	0.902	0.913	0.919	0.935	0.923	0.923	0.921	0.946	0.935	0.939
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Texas Statewide MOVES Fuel Engine Fractions Inputs Summary (model years 2050 back through 1990)-Continued

SUT	Fuel Type	Model Year														
		2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
MC	Gas	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PC	Gas	0.997	0.996	0.996	0.997	0.997	0.998	0.998	0.999	0.999	0.999	1.000	0.999	0.999	0.997	0.999
PC	Diesel	0.003	0.004	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.000	0.001	0.001	0.003	0.001
PT	Gas	0.982	0.982	0.983	0.989	0.992	0.981	0.993	0.992	0.981	0.995	0.991	0.986	0.985	0.994	0.989
PT	Diesel	0.018	0.018	0.017	0.011	0.008	0.019	0.007	0.008	0.019	0.005	0.009	0.014	0.015	0.006	0.011
LCT	Gas	0.951	0.951	0.956	0.908	0.949	0.929	0.950	0.927	0.971	0.932	0.974	0.974	0.951	0.937	0.984
LCT	Diesel	0.049	0.049	0.044	0.092	0.051	0.071	0.050	0.073	0.029	0.068	0.026	0.026	0.049	0.063	0.016
IBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TBus	Gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TBus	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SBus	Gas	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.042	0.114	0.147	0.121	0.010	0.090	0.124
SBus	Diesel	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.958	0.886	0.853	0.879	0.990	0.910	0.876
RT	Gas	0.005	0.004	0.005	0.006	0.002	0.169	0.404	0.019	0.012	0.010	0.105	0.031	0.210	0.101	0.204
RT	Diesel	0.995	0.996	0.995	0.994	0.998	0.831	0.596	0.981	0.988	0.990	0.895	0.969	0.790	0.899	0.796
SUShT	Gas	0.257	0.251	0.275	0.302	0.363	0.325	0.413	0.415	0.383	0.623	0.502	0.490	0.494	0.507	0.545
SUShT	Diesel	0.743	0.749	0.725	0.698	0.637	0.675	0.587	0.585	0.617	0.377	0.498	0.510	0.506	0.493	0.455
SULhT	Gas	0.257	0.251	0.275	0.302	0.363	0.325	0.413	0.415	0.383	0.623	0.502	0.490	0.494	0.507	0.545
SULhT	Diesel	0.743	0.749	0.725	0.698	0.637	0.675	0.587	0.585	0.617	0.377	0.498	0.510	0.506	0.493	0.455
MH	Gas	0.570	0.590	0.600	0.630	0.660	0.680	0.710	0.740	0.770	0.790	0.820	0.850	0.850	0.850	0.850
MH	Diesel	0.430	0.410	0.400	0.370	0.340	0.320	0.290	0.260	0.230	0.210	0.180	0.150	0.150	0.150	0.150
CShT	Gas	0.077	0.086	0.093	0.096	0.110	0.110	0.109	0.122	0.119	0.208	0.100	0.104	0.116	0.142	0.137
CShT	Diesel	0.923	0.914	0.907	0.904	0.890	0.890	0.891	0.878	0.881	0.792	0.900	0.896	0.884	0.858	0.863
CLhT	Diesel	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

APPENDIX E – MOVES FUEL FORMULATION INPUTS FOR EACH SEASON BY AREA

E.1. Summer Gasoline Fuel Formulation Inputs to MOVES by District (used for Spring and Summer Seasons)

Field	Units	District				
		AUS, CRP, SAT, WAC	BMT	ELP	DAL, FTW	HOU
fuelFormulationID	-	18702	18705	18703	18714	18724
fuelSubtypeID	-	12	12	12	12	12
RVP	psi	7.80	8.80	7.00	7.00	7.01
sulfurLevel	ppm	10.00	10.00	10.00	10.00	10.00
ETOHVolume	vol. %	9.66	9.69	9.60	9.67	9.67
MTBEVolume	vol. %	0	0	0	0	0
ETBEVolume	vol. %	0	0	0	0	0
TAMEVolume	vol. %	0	0	0	0	0
aromaticContent	vol. %	25.35	28.93	26.67	14.74	15.62
olefinContent	vol. %	8.33	4.50	5.50	10.74	10.83
benzeneContent	vol. %	0.61	0.61	0.63	0.46	0.51
e200	vap. %	49.45	51.27	48.74	49.21	49.02
e300	vap. %	82.68	84.25	87.84	85.13	84.54
T50	°F	203.73	195.68	206.12	202.52	203.13
T90	°F	327.68	318.24	306.72	325.77	327.89

*

E.2. Winter Gasoline Fuel Formulation Inputs to MOVES by District (used for Fall and Winter Seasons)

Field	Units	District			
		AUS, BMT, CRP, SAT, WAC	ELP	DAL, FTW	HOU
fuelFormulationID	-	18102	18101	18114	18124
fuelSubtypeID	-	12	12	12	12
RVP	psi	11.82	11.36	10.85	10.85
sulfurLevel	ppm	10.00	10.00	10.00	10.00
ETOHVolume	vol. %	10.00	10.00	10.13	9.84
MTBEVolume	vol. %	0	0	0	0
ETBEVolume	vol. %	0	0	0	0
TAMEVolume	vol. %	0	0	0	0
aromaticContent	vol. %	17.63	21.36	15.44	13.88
olefinContent	vol. %	9.33	6.66	10.07	10.39
benzeneContent	vol. %	0.61	0.63	0.47	0.45
e200	vap. %	55.11	53.72	57.97	58.66
e300	vap. %	84.04	87.38	84.72	84.60
T50	°F	189.39	192.22	157.72	151.5
T90	°F	324.68	309.50	325.03	314.00

E.3. Diesel Fuel Formulation Inputs to MOVES (used for All Districts and Seasons)

Field	Units	Statewide
fuelFormulationID	-	30011
fuelSubtypeID	-	20
RVP	psi	0
sulfurLevel	ppm	11.00
ETOHVolume	vol. %	0
MTBEVolume	vol. %	0
ETBEVolume	vol. %	0
TAMEVolume	vol. %	0
aromaticContent	vol. %	0
olefinContent	vol. %	0
benzeneContent	vol. %	0
e200	vap. %	0
e300	vap. %	0
T50	°F	0
T90	°F	0

APPENDIX F – MOVES I/M COVERAGE INPUTS

Vehicle I/M programs exist in 17 Texas counties: six in Houston, eight in DFW, two in Austin, and El Paso County. TTI modeled I/M effects in ERLTs for each district where its representative county required an I/M program. Table F.1 lists the TxDOT districts and their counties, identifying I/M counties using bold-italic text. I/M programs were thus modeled for the Austin, Dallas, El Paso, Fort Worth, and Houston districts, also denoted by bold-italic text. TTI set up MOVES I/M coverage inputs to represent Texas program designs specified in the Texas I/M SIP and Texas rules. For the ERLT analysis years (2020 – 2050), the I/M testing required, predominantly on light-duty vehicles up to 8,500 pounds gross vehicle weight, is consistent across all I/M areas, including annual testing of gasoline vehicles within a 2-through-24-year vehicle age window (excluding motorcycles; and military tactical, diesel-powered, and antique vehicles). Gas cap integrity tests and On-Board Diagnostics (OBD) tests are required.

For additional I/M program details, see the current I/M SIP and/or pertinent Texas Administrative Code. (*14*)

F.1. Inspection and Maintenance Program Modeling for ERLTs by District.

TxDOT District[1]	Counties in the District[1]	Representative County[1] for Emission Rate Runs
1. Austin	Bastrop, Blanco, Burnet, Caldwell, Gillespie, Hays, Lee, Llano, Mason, ***Travis***, ***Williamson***	***Travis***
2. Beaumont	Chambers, Hardin, Jasper, Jefferson, Liberty, Newton, Orange, Tyler	Jefferson
3. Corpus Christi	Aransas, Bee, Goliad, Jim Wells, Karnes, Kleberg, Live Oak, Nueces, Refugio, San Patricio	Nueces
4. Dallas	***Collin***, ***Dallas***, ***Denton***, ***Ellis***, ***Kaufman***, Navarro, ***Rockwall***	***Dallas***
5. El Paso	Brewster, Culberson, ***El Paso***, Hudspeth, Jeff Davis, Presidio	***El Paso***
6. Fort Worth	Erath, Hood, Jack, ***Johnson***, Palo Pinto, ***Parker***, Somervell, ***Tarrant***, Wise	***Tarrant***
7. Houston	***Brazoria***, ***Fort Bend***, ***Galveston***, ***Harris***, ***Montgomery***, Waller	***Harris***
8. San Antonio	Atascosa, Bandera, Bexar, Comal, Frio, Guadalupe, Kendall, Kerr, McMullen, Medina, Uvalde, Wilson	Bexar
9. Waco	Bell, Bosque, Coryell, Falls, Hamilton, Hill, Limestone, McLennan	McLennan

[1] The 17 counties in the bold-italic text require vehicle I/M Programs. The ERLTs for the five TxDOT districts (and their representative counties) in bold-text were modeled with MOVES I/M coverage inputs. MOVES adjusts emissions (HC, CO, and NO_X) to incorporate the benefits of the local I/M program design defined using the MOVES I/M coverage table input parameters.

14. Revision to the State Implementation Plan Mobile Source Strategies, Inspection and Maintenance State Implementation Plan Revision, TCEQ, adopted February 12, 2014.

APPENDIX G – MOVES HOTELLING ACTIVITY DISTRIBUTION INPUTS

G. Hotelling Activity Distributions by Model Year

Begin Model Year	End Model Year	Op Mode Fraction for op Mode ID/op Mode Name			
		200	201	203	204
		Extend Idling	Diesel Aux	Battery AC	APU Off
1960	2009	0.8	0	0	0.2
2010	2020	0.73	0.07	0	0.2
2021	2023	0.48	0.24	0.08	0.2
2024	2026	0.4	0.32	0.08	0.2
2027	2050	0.36	0.32	0.12	0.2

Source: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/582177430806-20191201-TTI-HeavyDutyVehicleIdleActivityStudy.pdf (See Table 18, Page 79).

APPENDIX H – TIME OF DAY VMT MIXES

Appendix H is being submitted as an electronic appendix.

APPENDIX I – HOURLY VMT DISTRIBUTIONS BY AREA

I.1. Austin District Weekly Hourly VMT Factors

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.052965
	8	0.061358
	9	0.057668
Mid-Day	10	0.054863
	11	0.053117
	12	0.055446
	13	0.05719
	14	0.057944
	15	0.059662
	16	0.061844
PM Peak	17	0.06163
	18	0.061642
	19	0.058603
Overnight	20	0.049941
	21	0.040588
	22	0.03543
	23	0.028022
	24	0.019985
	1	0.012212
	2	0.008652
	3	0.008061
	4	0.007098
	5	0.010124
	6	0.025953

*Note: Hour ID 1 is 12-1 a.m., etc.

I.2. Beaumont District Weekly Hourly VMT Factors

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.046245
	8	0.059776
	9	0.053133
Mid-Day	10	0.050217
	11	0.053887
	12	0.058802
	13	0.061864
	14	0.062945
	15	0.064254
	16	0.069988
PM Peak	17	0.072514
	18	0.07025
	19	0.05679
Overnight	20	0.04384
	21	0.035264
	22	0.028118
	23	0.020609
	24	0.014426
	1	0.009154
	2	0.006776
	3	0.006225
	4	0.007725
	5	0.014984
	6	0.032214

*Note: Hour ID 1 is 12-1 a.m., etc.

I.3. Corpus Christi District Weekly Hourly VMT Factors

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.046947
	8	0.066988
	9	0.059656
Mid-Day	10	0.051228
	11	0.051037
	12	0.055465
	13	0.058486
	14	0.059043
	15	0.060678
	16	0.067442
PM Peak	17	0.07712
	18	0.090915
	19	0.064468
Overnight	20	0.044187
	21	0.033644
	22	0.026887
	23	0.019692
	24	0.013164
	1	0.007062
	2	0.004392
	3	0.003932
	4	0.004134
	5	0.008892
	6	0.024542

*Note: Hour ID 1 is 12-1 a.m., etc.

I.4. Dallas District Weekly Hourly VMT Factors

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.054744
	8	0.064486
	9	0.058177
Mid-Day	10	0.0512
	11	0.049153
	12	0.051312
	13	0.054107
	14	0.055567
	15	0.059067
	16	0.064128
PM Peak	17	0.068798
	18	0.069664
	19	0.06126
Overnight	20	0.048138
	21	0.038268
	22	0.033022
	23	0.02654
	24	0.018604
	1	0.010622
	2	0.007152
	3	0.006643
	4	0.007043
	5	0.011987
	6	0.030318

*Note: Hour ID 1 is 12-1 a.m., etc.

I.5. El Paso District Weekly Hourly VMT Factors

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.036083
	8	0.06406
	9	0.067877
Mid-Day	10	0.057882
	11	0.053617
	12	0.055839
	13	0.058681
	14	0.060008
	15	0.062088
	16	0.067648
PM Peak	17	0.072066
	18	0.072809
	19	0.061803
Overnight	20	0.047398
	21	0.037265
	22	0.031047
	23	0.024516
	24	0.017562
	1	0.010156
	2	0.006856
	3	0.005587
	4	0.005296
	5	0.00726
	6	0.016596

*Note: Hour ID 1 is 12-1 a.m., etc.

I.6. Fort Worth District Weekly Hourly VMT Factors

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.051454
	8	0.070478
	9	0.061748
Mid-Day	10	0.051306
	11	0.049612
	12	0.052879
	13	0.055248
	14	0.056798
	15	0.060701
	16	0.069633
PM Peak	17	0.078678
	18	0.081842
	19	0.062755
Overnight	20	0.043406
	21	0.032762
	22	0.027327
	23	0.021383
	24	0.014758
	1	0.008643
	2	0.005547
	3	0.005073
	4	0.005097
	5	0.009014
	6	0.023856

*Note: Hour ID 1 is 12-1 a.m., etc.

I.7. Houston District Weekly Hourly VMT Factors

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.063059
	8	0.067223
	9	0.057638
Mid-Day	10	0.051765
	11	0.050444
	12	0.052234
	13	0.054048
	14	0.054935
	15	0.057997
	16	0.063827
PM Peak	17	0.06853
	18	0.070846
	19	0.059527
Overnight	20	0.046397
	21	0.03523
	22	0.029954
	23	0.023328
	24	0.015757
	1	0.008698
	2	0.005769
	3	0.005419
	4	0.006065
	5	0.013122
	6	0.038191

*Note: Hour ID 1 is 12-1 a.m., etc.

I.8. San Antonio District Weekly Hourly VMT Factors

Period	Hour ID	VMT Factor Mean
AM Peak	7	0.051302
	8	0.068599
	9	0.060091
Mid-Day	10	0.04972
	11	0.048523
	12	0.051535
	13	0.05426
	14	0.056179
	15	0.060185
	16	0.069091
PM Peak	17	0.077362
	18	0.079121
	19	0.063029
Overnight	20	0.045084
	21	0.035508
	22	0.030177
	23	0.023889
	24	0.016696
	1	0.009472
	2	0.006529
	3	0.005785
	4	0.006053
	5	0.009541
	6	0.022269

*Note: Hour ID 1 is 12-1 a.m., etc.

I.9. Waco District Weekly Hourly VMT Factors

Period	Hour ID	Factor
AM Peak	7	0.036347
	8	0.051794
	9	0.048349
Mid-Day	10	0.049058
	11	0.053763
	12	0.058636
	13	0.061325
	14	0.06324
	15	0.065817
	16	0.067988
PM Peak	17	0.07006
	18	0.069874
	19	0.057015
Overnight	20	0.046477
	21	0.039781
	22	0.033305
	23	0.026119
	24	0.01966
	1	0.014142
	2	0.011518
	3	0.010312
	4	0.010703
	5	0.013371
	6	0.021344

*Note: Hour ID 1 is 12-1 a.m., etc.

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